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The Trilemma: An Empirical Assessment over 35 years since the 1970s

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Abstract:

This research provides further insight of trilemma phenomenon which is defined as the impossibility for a country to achieve at the same time the triple desirable goals of stability of its exchange rate, independence of its monetary policy and freedom of its capital flows. Using three indices measuring these three variables, we prove that the trilemma relationship exists provided some extra explanatory variables are added in the econometric fixed-effect model's equation. Conditionality is therefore attached to the existence of the trilemma. Once these results are established we provide some additional analyses of the trilemma phenomenon. First, by introducing the concept of "performance" we show that certain countries are coping better than others facing the trilemma constraint. Second, by using a triangle graph representing the trilemma goals at the vertices, we analyze the tradeoff that countries have adopted over years when dealing with this problem. We manage to show graphically that, rather than positioning themselves to the vertices of this triangle, countries usually adopt positions close to one side of it. These results can therefore be understood as the choice between three "dilemmas" represented by the triangle's sides.

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I. Introduction

Throughout the course of economic history, based on the analysis of the failure of monetary systems, researchers in the macroeconomic field have been able to isolate a phenomenon formulated as the following rule: it is impossible for a country to achieve simultaneously the triple contradicting, but desirable goals of fixing its exchange rate (to foster stabilization of trade and growth), of running an independent monetary policy (to achieve domestic monetary policy goals) and of freeing completely its capital flows (for an optimal allocation of resources). One of these three goals has to be given up to achieve the two others. Stated in other terms, a country is left with the following 3 choices:

- Fix its exchange rate; run an independent monetary policy; restrict capital flows. (1)
- Fix its exchange rate; give up monetary policy independence; free capital flows. (2)
- Let the exchange rate float; run an independent monetary policy; free capital flows. (3)

The paternity of the discovery of this rule is usually attributed to Mundell (-1961-, -1968-) who highlighted the phenomenon in his researches in the 1960s, giving it the name of *triangle of incompatibility* (Benassy-Quéré, Coeuré, Jacquet, Pisany-Ferry, -2004-) or *incompatible trinity* (Krugman -2000-). Looking at the history of research carried out about this phenomenon one can notice that economists have maintained some uncertainty concerning its real appellation, leading to various catchy expressions trying to summarize it, either by emphasizing the three goals to achieve (*"The holy trinity"* see Rose -1996-), or the impossibility arising from conflicting goals (*"Impossible theorem"* see Isard -1995-), or both (the *"Triad of incompatibilities"* see Fischer, Reisen -1993-, the *"Impossible trinity"* see Fischer -2001-, Ghosh, Gulde, Wolf -2002-, Joshi -2003-). Through the progress of research, probably under the influence of its main advocates Obstfeld and Talyor, another name, "*The Trilemma*" (Obstfeld, Taylor -1997-, Obstfeld, Shaumbaugh, Taylor -2005-) seems however to have prevailed among scholars. This appellation, based on the root of the "dilemma" but with a "tri-" to

illustrate the triple choice has the advantage not only of being self explanatory but also to recall the dilemma occurring between fixed and flexible exchange rate.

As mentioned in the first paragraph, capturing the phenomenon of the trilemma was at first a historical matter, economists starting to suspect its existence by observing the collapse of different monetary systems throughout time. In regard to the trilemma, it is common to distinguish roughly three periods in which one of the trilemma solutions was adopted (Obstfeld, Taylor -1997-, Fukao -2000-). First is the Gold Standard period during which exchange rates were fixed, capital flows free, but monetary policy not independent (case 2 of the first paragraph). After this era came the Bretton Woods system, period during which exchange rates were fixed, monetary policy independent, but capital flows rather restricted (case 1 in the first paragraph). Finally came the post Bretton Woods era which started in the beginning of the 1970s when countries entered a period of free float of exchange rates, independence of monetary policy and free flow of capital (case 3 in the first paragraph).

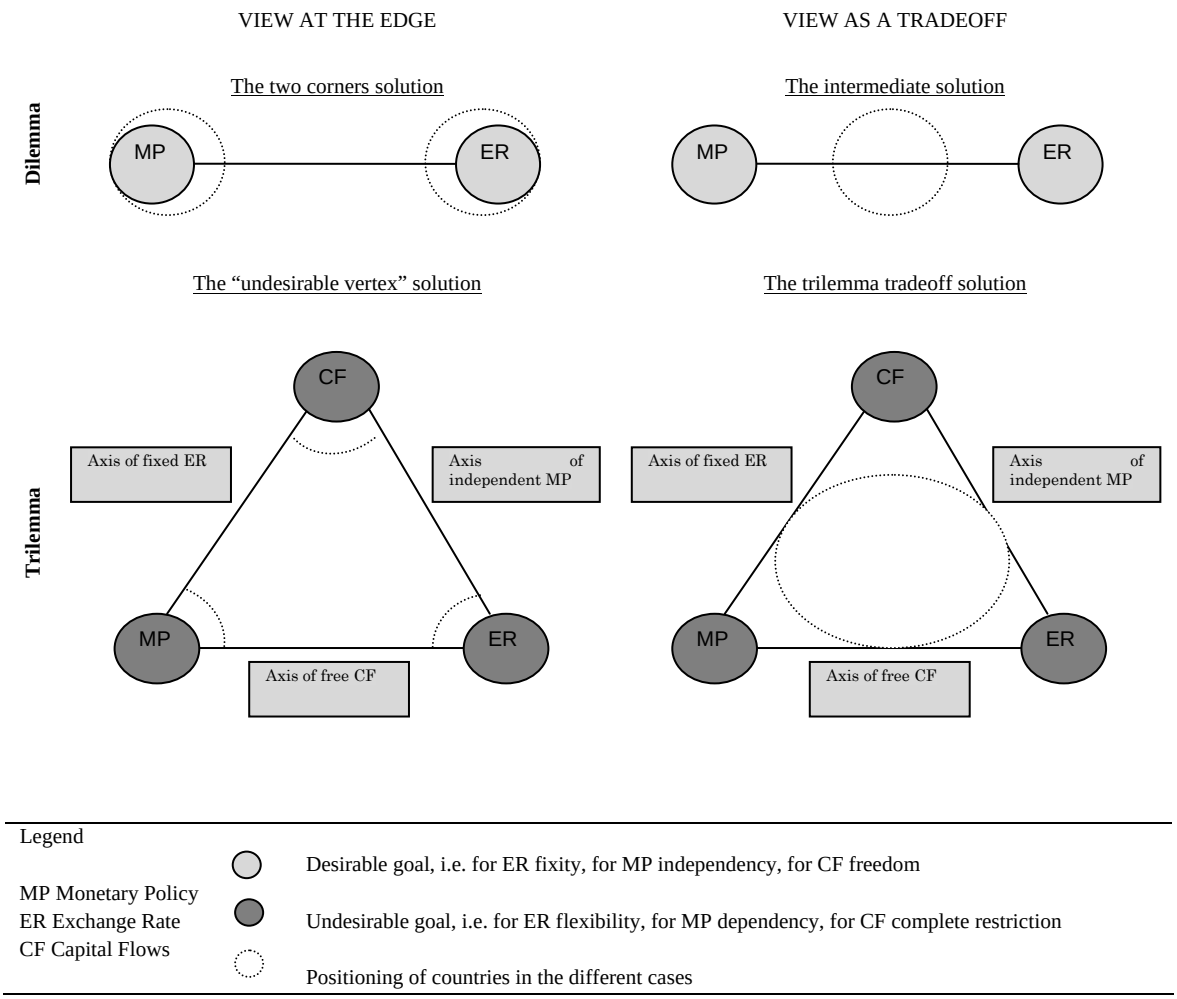
Distinguishing those three periods was of high interest because the failures of the monetary systems that were in place during those eras could be explained by the emergence of economic environments that were not sustainable according to the trilemma rule. Hence for example, in the first case, the Gold Standard which featured fixed exchange rate, free flows of capital and non independent monetary policy was able to hold because countries were not seeing a drop of the latter as such a big loss inducing high costs. Hence the maintenance of the system was carried out through high credibility and cooperation among countries to maintain the parity to gold (and therefore drop monetary policy independence) which was made possible because the pressure on monetary policy to achieve domestic goals was not very high at that time. Indeed, the work force was still not organized properly in unions, and demand for monetary policy promoting employment was not a crucial goal. However, the collapse of the system occurred once pressure on governments to act domestically became stronger. (Eichengreen -1996-). In the second case, the collapse of the Bretton Woods system, which featured fixed exchange rate, independence of monetary policy and no freedom of capital flows became unsustainable after the mid 1960s when pressure on the rising amount of capital flows to freely move became too strong. The post Bretton Woods period has been mainly characterized by free floats of the exchange rate (monetary

policy being independent and capital flows free). In this era, no system had to be maintained so the terminology of failure does not really apply, but what was mainly underlined by economists were the regional crises that occurred when countries tried to fix their exchange rate while keeping the post Bretton Woods "characteristics" of free flows of capital and monetary policy independence (European crisis with the German reunification in 1992-93, Asian Crisis in 1997, etc…).

What should be underlined is that after the Bretton Woods system's collapse and until the present times, exchange rate economics (especially the choice of an exchange rate regime) together with the liberalization of capital flows became a crucial matter (Isard -1995-). That is what explains that most of the time, when not tackling directly the issue of the existence of the trilemma, the literature mentioning it and treating one side of it splits into two fields: exchange rate regime choice and capital account liberalization. Perhaps the easiest way to understand the stake and problems that the trilemma brings about is to put it into perspective with the "two corners solution" or "bipolar view" literature that gathered attention of economists (or the "dilemma between fixed exchange rate and flexible exchange rate) concerning the choice between fixed exchange rate and flexible exchange rate (Fischer -2001-).

The dilemma between fixed exchange rate system and flexible exchange rate, as the *scheme 1* shows us, is indeed just a particular case of the trilemma. After the collapse of the Bretton Woods System when exchange rate macroeconomics became a crucial topic among scholars it was somehow taken for granted that capital flows were to be "freed" or at least that freeing them did not represent any conflicting goal with the choice between a fixed or flexible exchange rates system. At that time therefore, countries were facing a dilemma between fixing their exchange rate or letting it float, the former case being equal to a loss of monetary policy independence. Scholars dealing with the choice of an exchange rate system were rather talking of the choice between a fixed exchange rate system or a free float system, but if one makes use of the concept of monetary policy independence instead, it is possible to present it as the dilemma between monetary policy independence (or in negative terms of free float of the exchange rate) and fixed exchange rate (or in negative term loss of independence of monetary policy).

Scheme 1: Dilemma versus trilemma



This case is illustrated in the upper part of the table of *Scheme 1*, where the line represents the choice between the two possibilities mentioned. The existence of such a dilemma is acknowledged by researchers, and the debate taking place around it is about the sustainability of intermediate systems versus solutions at the corners, meaning that countries have no choice but to choose between fixing completely the exchange rate or letting it float to have independence of monetary policy. This choice is represented in *Scheme 1* at the top part, under the columns "view at the edge" or "view as a tradeoff".

Advocates of the trilemma would consider the dilemma debates, as we have mentioned previously, as a particular case of the trilemma, and therefore somehow insufficient in terms of analysis. If the trilemma does exist then capital flows should be taken into account because governments would subsequently possess an extra economic

tool (regulation of capital flows freedom) which could have important macroeconomic policy implications. However, unlike the dilemma whose existence has been widely proved econometrically in the literature, such is not the case for the trilemma. The main studies existing on the trilemma topic are from Obstfeld, Shambaugh, Taylor (2005), and Rose (1996). Rose does not find results to support the idea of the existence of an incompatibility between the three variables, while on the contrary, Obstfeld, Shambaugh, and Taylor find that the trilemma exists, and that it should be a framework to consider for policy makers.

While exposing our own work whose first aim is to proceed to a new assessment of whether the trilemma exists or not, we will have a chance to mention the methodology adopted in the above mentioned articles during our study and comment on the differences in approaches. Proof of the existence of the trilemma requires indeed ways of measuring the three variables involved in it (exchange rate volatility, monetary policy independence, capital flows freedom), and approaches can be different according to the way those variables are treated. Here what we would like to stress is that, the authors who have proved the existence of the trilemma (Obstfeld, Shambaugh, Taylor -2005-) seem to have adopted, although it is not mentioned explicitly in their article, a definition of this phenomenon as a “tri-lemma” strictly speaking. Indeed, they restrict themselves to what we could call a narrow definition of the trilemma in the sense that they consider the trilemma choice as exclusive, the abandoned “good side” of one variable (stability of exchange rate or independence of monetary policy or capital flows freedom) being completely abandoned. In that sense, it seems that the authors position themselves at the “vertices” on Mundell’s triangle of incompatibility illustrated at the bottom left of *Scheme 1*. This triangle can be found in some articles and textbooks (Frankell -1999-, Benassy-Quéré, Coeuré, Jacquet, Pisany-Ferry -2004-, Kamar -2005-, Krugman, Obstfeld -2006-), although the positioning and meaning of the vertices (whether the vertex is one of the three “ideal” goals or not) of the triangle can vary from one representation from another. Here, for reasons that will be explained again in *Part VI* of this article we have adopted the representation on which vertices represent the non desirable goals. The further away from one vertex a country is, the better it is. Hence for example, a country that would position itself close to the axis opposite to the vertex ER would value fixed exchange rate the most. The same reasoning applies to the vertices

MP and CF which represent respectively full "dependence" of monetary policy and complete restriction of capital flows. Drawing a parallel to the tradeoff view of the dilemma (see *Scheme 1* bottom right), another main objective of this study is to try to understand what kind of positioning countries have adopted in Mundell's triangle, and see if one should rather speak of an "undesirable" vertex solution or a real tradeoff adopted by countries, and that could take some particular shape inside the triangle.

This article is built as follows: *Part II to IV* is devoted to the assessment of the trilemma existence, including the explanation of the calculation of indices ER, MP, and CF. *Part V* is devoted to the analysis of performance of countries regarding the trilemma constraint. Finally, we finish in *Part VI* by the assessment of the tradeoff of countries mentioned in the previous paragraph.

II. A first step: the classical dilemma relationship

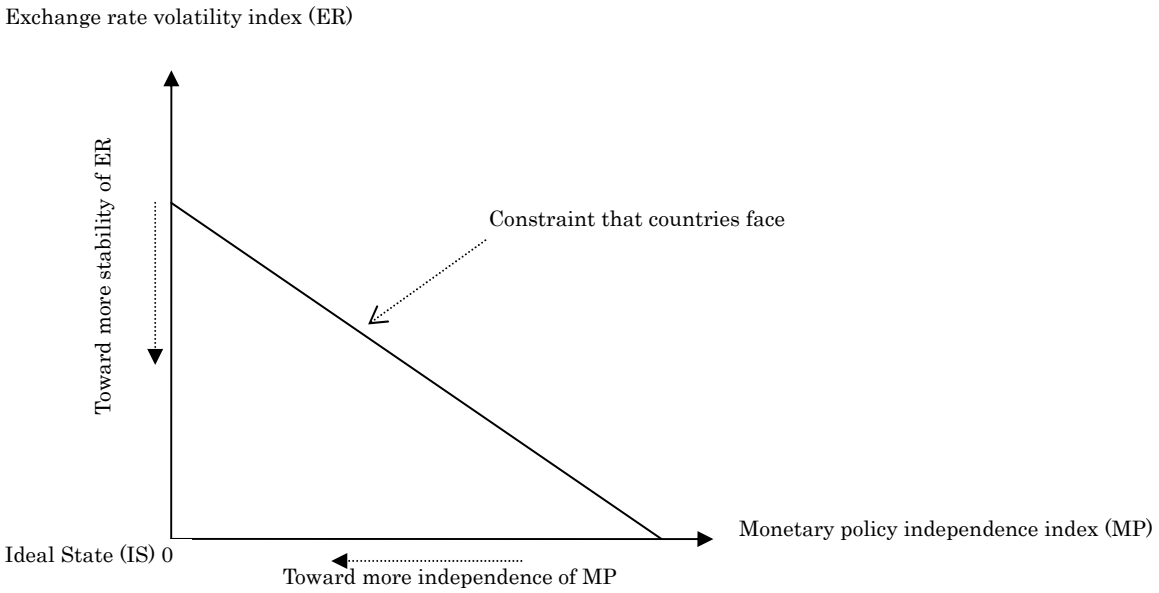
Prior to tackling the trilemma relationship we will first, in this part, present the classical dilemma relationship between independence of monetary policy and stability of exchange rate.

1. Methodology

In order to observe the dilemma between independence of monetary policy (MP) and stability of exchange rate (ER), we first define an ideal state (IS) that countries are willing to achieve, in which MP is completely independent and the ER perfectly stable. If the dilemma exists, this ideal state should not be reachable (by definition), and one should be able to observe empirically the constraint that each country is facing. Once its existence is proved, our objective is to analyze whether or not capital flows affect this constraint in order to confirm or reject the hypothesis of the existence of the trilemma relationship. The two indices are calculated so that the value 0 represents the ideal state we have defined, i.e. a fully independent monetary policy and a perfectly stable exchange rate. This value 0 is not reachable since by definition of the dilemma increasing the stability of the exchange rate (going towards the value 0 for the index "stability of exchange rate") means giving up some monetary policy independence

(going further away from the value 0).

Graph 1: The dilemma constraint



In other words, monetary policy independence index will increase as the value of the index for exchange rate decreases. The approach we just explained is summarized in *Graph 1.*

2. Calculation of the indices

a. Exchange rate volatility index (ER)

The exchange rate volatility index calculations are detailed in *Appendix 1* of the appendix section. We selected 56 countries[1] from the JP Morgan monthly real effective exchange rate (REER)[2] database which covers a time period from January 1970 to August 2004. The panel is split into 4 periods: 3 decades for the 1970s, 1980s, and 1990s, and 5 years for the last period starting from January 2000 and ending in August 2004. The index is the standard deviation of the logarithm of the data per period of time

[1] For the last period of the panel the entity "Euro zone" replaces the countries belonging to this currency area.
[2] REER is taken because we want to check what the countries do in reality, and not what is announced (see Obstfeld, Taylor, Shambaugh -2005-, Reinhart, Rogoff -2004-, Levy-Yeyati, Sturzenegger -2000-) assuming what they achieve was the best they could do so that we can interpret what we see in reality as a "constraint".

for one country, normalized to the average of the whole sample. The way of calculating the index fits therefore our definition of the ideal state, since the value 0 represents a complete stable exchange rate (null standard deviation value). The figures obtained by those calculations can be seen in *Table 1*. The average of the panel is 1.00 and the standard deviation 0.70. The decade of the 1980s shows the highest volatility which corresponds to the historical period of financial deregulation that has lead to more volatility of exchange rate system. After the 1980s one can observe a decrease in the exchange rate volatility which reaches its lowest level in the 2000s with 0.74 for the index value. The standard deviation follows a similar pattern as the exchange rate, reaching its peak in the 1980s while decreasing afterwards.

The highest value for volatility differs from one period to another, being respectively Portugal in the 1970s, Ecuador in the 1980s, Kuwait in the 1990s and Argentina in the 2000s. Countries with the lowest volatility are usually among European countries (Belgium -1970s-, Italy -1980s-, Norway -1990s-). For the 2000s period the lowest volatility value is Panama.

Table 1: ER index main values

Descriptive Stat. ER	1970s	1980s	1990s	2000s	Panel
Average	1.00	1.30	1.00	0.74	1.00
Standard deviation	0.65	0.82	0.71	0.52	0.70
Maximum Value	3.14	3.30	3.46	3.00	3.46
Minimum Value	0.28	0.31	0.24	0.23	0.23

b. Monetary policy independence index (MP)

The monetary policy independence index calculations can also be seen in *Appendix 1*. The independence of the monetary policy is measured by the coefficient of correlation between country *i* 's monthly interest rate, and the average monthly interest rate of 4 main countries (US, UK, Germany, and Japan), to which we added the value 1 and normalized to the mean of the whole panel (see formula of *Appendix 1*). The monthly interest is taken from the IFS database and corresponds to the money market rate or call money rate (line 60B of the database). When the money market rate was not

available, we took the most appropriate interest rate existing for the country. The countries for which another interest rate has been chosen are listed in *Appendix 1*.

In order to remain consistent with the definition of the ideal state presented in the first paragraph of this section, we have added the value 1 to the coefficient of correlation. The coefficient of correlation having a value ranging from -1 to 1, adding 1 allows us to obtain 0 as the minimum value for perfect independence of the monetary policy. This implies that prior to adding the value 1, we have assumed the following hypothesis:

- A value of 1 showing perfect correlation implies full "dependence" of the monetary policy, the country correlated to the value of the basket just following the trends of the major currencies.
- On the contrary a value of -1 implies a perfect independence of the monetary policy, the country being free to run its policy completely differently than the trend of the basket.

We acknowledge that this way of defining the independence might lead to controversy concerning the value -1, or strong negative values. It raises the question of whether a complete opposite movement compared to the basket is a sign of independence or of dependence. One might assert that countries moving opposite to the trend of the basket are constrained to do so and are therefore not independent at all. However it seems more relevant to us that such countries, if they indeed exist, are more likely to be called "independent" for their monetary policy. Following the trend of the basket in terms of interest rate is with no doubt a sign of dependency, taking the opposite trend seems rather to be a sign of independence, of an individually thought of monetary policy. In any case, if we look at the data prior to adding the value 1 to the coefficient of correlation, out of 163 observations available only 24 have a negative value. Those negative values are mainly low (average of -0.23), the strongest negative values being South Africa in the 1970s (-0.45), Ecuador (-0.5) and Mexico (-0.71) in the 1980s. Strong negative values are therefore scarce. Moreover countries with such values often tend to display a high volatility for their exchange rate, which corroborates our assumption of more independence of their monetary policy.

Another remark that we should add here is concerning the way of measuring countries' monetary policy independence. Unlike previous articles (Shambaugh -2004-,

Obstfeld, Shambaugh, Taylor, -2005-), we use the same monetary base for all the countries of the panel by building a "world interest rate" and do not adjust each monetary base according to which countries are pegging their currency. We adopt this way of measuring monetary policy independence to stay consistent with our measurement of exchange rate volatility. Our approach can be also understood as being a "global" approach in the sense that, economies of the world being closely intertwined, the interest rate they follow is not so straightforward. Even pegging its own currency to one major developed economy does not mean for a country that it has completely lost its independence. It has lost it compared to the country it pegged, but that might be a strategy in return to be more independent toward another economy. Moreover, pegs are never so clearly defined nor indefinitely set, and there is always room for a country to move toward other directions in terms of monetary policy. It is precisely this area of uncertainty and complexity that the "world interest rate" we have built tries to capture.

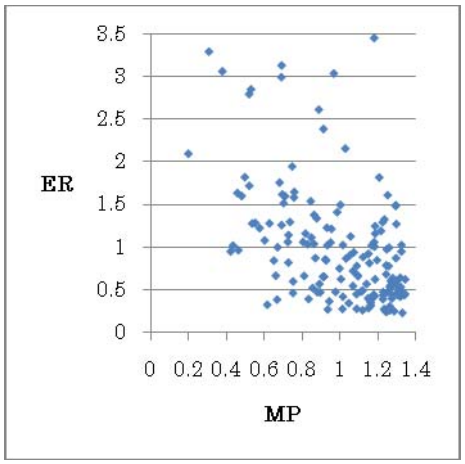
Table 2: MP index main values

Descriptive Stat. MP	1970s	1980s	1990s	2000s	Panel
Average	0.90	0.92	1.04	1.08	1.00
Standard deviation	0.24	0.34	0.23	0.25	0.27
Maximum Value	1.30	1.34	1.33	1.35	1.35
Minimum Value	0.38	0.20	0.48	0.42	0.20

Table 2 shows some of the descriptive statistics relating to the MP index. On average, the level of independence does not seem to vary so much over time, although one can observe a slight increase of monetary "dependence" from the 1990s. This trend matches well the decreasing volatility of ER in the two decades after the 1990s. For standard deviation, only the 1980s show a relatively big difference compared to the other periods. This higher value can be interpreted as a wider range of monetary policy adopted during the 1980s, some countries choosing more independence to carry out domestic goals, such as mitigating inflation rates. The highest value of the index MP is taken by various countries over time, although its level does not vary much from one period to another, (1970- Thailand, 1980s – Belgium, 1990s- Finland, 2000s-Saudi Arabia). The lowest value shows a sharp difference in the 1980s with a value of 0.20

compared to a value ranging from 0.38 to 0.48 for the 3 other decades. The lowest values, i.e. the most independent monetary policy for the 4 decades are respectively South Africa in the 1970s, Mexico in the 1980s, Romania in the 1990s, and Brazil in the 2000s.

Graph 2: Plot ER-MP whole panel



Graph 2 shows the plot ER-MP, giving a first sense of the appearance of the dilemma constraint over the whole period of the panel. We shall now examine how valid this relationship is on an econometric basis.

3. Econometric analysis of the dilemma

In this section we check how well the dilemma model fits our hypothesis of the previous section, i.e. checking if the constraint countries face is econometrically significant. The tested equations are as follows:

Cross-section:

$$ER_{it} = \alpha_i + \beta MP_{it} + \varepsilon_{it} \quad and \quad ER_{it} = \alpha_i + \beta lnMP_{it} + \varepsilon_{it}$$

Fixed-effect:

$$ER_{it} = \alpha_i + \beta MP_{it} + \sum_{t=2}^{4} \omega_t Year\_dummy_t + \sum_{i=1}^{n-1} \delta_i Country\_Dummy + \varepsilon_{it}$$

$$ER_{it} = \alpha_i + \beta lnMP_{it} + \sum_{t=2}^{4} \omega_t Year\_dummy_t + \sum_{i=1}^{n-1} \delta_i Country\_Dummy + \varepsilon_{it}$$

Where *i* denotes the countries, *t* the 4 periods of time of the panel (1970s, 1980s, 1990s

and 2000s) detailed in *Appendix 1*, and n the number of countries.

Expected sign $\beta < 0$

The dilemma constraint should give us a negative significant relationship between ER and MP, illustrating the fact that an increase in monetary policy independence (the index MP becomes smaller) should lead to an increase in exchange rate volatility (the index ER becomes higher).

Table 3: The dilemma between exchange rate volatility (ER) and independence of monetary policy (MP)

Dependent variable ER / Regression with MP						
Variables	OLS cross-section 1970s	OLS cross-section 1980s	OLS cross-section 1990s	OLS cross-section 2000s	OLS pooled	Fixed-effect
Observations	n=26	n=35	n=53	n=45	n=159	n=159
MP	-0.89* (0.47)	-1.19*** (0.35)	-1.48*** (0.40)	-1.28*** (0.25)	-1.25*** (0.18)	-0.51** (0.22)
Yeardummy 80s					0.31** (0.15)	0.21 (0.13)
Yeardummy 90s					0.24* (0.14)	-0.001 (0.13)
Yeardummy 00s					0.03 (0.15)	-0.33** (0.15)
Constant	1.75*** (0.44)	2.33*** (0.34)	2.56*** (0.42)	2.14*** (0.28)	2.07*** (0.20)	1.54*** (0.21)
Dependent variable ER / Regression with LnMP						
LnMP	-0.91** (0.36)	-0.90*** (0.25)	-1.35*** (0.36)	-1.11*** (0.23)	-1.03*** (0.14)	-0.50*** (0.17)
Yeardummy 80s					0.26* (0.15)	0.19 (0.13)
Yeardummy 90s					0.23 (0.14)	0.016 (0.13)
Yeardummy 00s					0.003 (0.15)	-0.32** (0.14)
Constant	0.81*** (0.12)	1.08*** (0.12)	1.03*** (0.09)	0.80*** (0.06)	0.80*** (0.12)	1.00*** (0.11)

The standard error value is in brackets
*sf=significance level *** sf<1% **1%<sf<5% * 5%<sf<10%*

Table 3 shows the results of a series of 12 regressions, testing the hypothesis of the dilemma constraint. These regressions are split into two groups depending on whether MP or LnMP are used as an explanatory variable. The first four regressions of each series show the results of the cross-section regressions for each period of the panel, the last two pooled data for OLS and fixed-effect. As we can see the overall result of those regressions seems to show us a very significant relationship between ER and MP (or LnMP) with the expected minus sign. For the cross-section however the period 1970s is sensitive to the outlier South Africa (with MP also to Belgium and Ireland) but those non-robust results can be easily explained by the lack of data in this period (only 26). For the other regressions, whether including MP or LnMP, cross-sections OLS, pooled OLS, and fixed-effect model all show very significant and robust results.

The slope of all the regressions has the expected negative sign, illustrating the fact that countries, as they fix their exchange rate more, lose some independence of their monetary policy, which backs up our assumption of the existence of the dilemma relationship. In the fixed-effect, *Year Dummy 2000s* displays significant results, with a negative impact on ER, which shows that this decade is marked by a lessening of the exchange rate volatility compared to the base dummy decade of the 1970s.

III. The capital flows restriction index (CF)

Having proved the existence of the classical dilemma relationship between our indices ER and MP, we want to check if capital flows have an influence on this relationship, in other words, if one is allowed to talk about the existence of a trilemma relationship between monetary policy independence, exchange rate volatility and capital flows freedom. In order to do so, we need to build an index enabling us to measure the level of capital flows restriction of each country in our panel.

1. The AREAER literature review

In order to measure capital flows restriction we will use, as many studies have previously done so (see text after *Table 4*), the AREAER (Annual Report on Exchange Arrangements and Exchange Restrictions) published yearly by the IMF since 1950. We

will first briefly present this AREAER source and some existing literature on the topic.

Table 4 presents roughly the contents of an AREAER book and the evolution of trade, exchange, and capital restrictions categories over years. It shows us that an AREAER book is composed, depending on the year, either by some text describing restrictions with few categories (1950-1967), text and old classification mainly focusing on restrictions on trade (1968-1996), and text and a new classification focusing mainly on capital restrictions (from 1997).

One of the most challenging problems to build an index of capital flows restriction from the AREAER is to be able to bridge the gap between changes that have occurred in those classifications, the 1968-1996 summary table having almost no link with the new system of classification adopted in the 1997 report.

Table 4: Contents[1] of the AREAER and evolution in terms of classification

1950-1967[2]	1968-1996	1997- …
Text description country by country of different practices concerning mainly restrictions on trade exchange.	Text description country by country of different practices concerning mainly restrictions on trade exchange.	Text description country by country of different practices concerning mainly restrictions on capital flows.
No summary table	Summary table listing mainly 11 categories of restrictions[3] 1.Special rate(s) for some or all capital transactions and / or some invisibles 2.Import rates(s) different from export rate(s) 3.More than one rate for imports 4.More than one rate for exports 5.Restrictions exists on payments in respect of current transactions **6.Restriction exists on payments in respect of capital transactions** 7.Bilateral payments arrangement with members 8.Bilateral arrangement with non members 9.Import surcharges 10.Advance import deposit 11.Surrender of export proceeds required	Summary table at the end of the book listing 13 categories of restrictions **1.Capital market securities** **2.Money Market Instrument** **3.Collective investment securities** **4.Derivatives and other instruments** **5.Commercial credits** **6.Financial credits** **7.Guarantees, sureties and financial backup facilities** **8.Direct investment** **9.Liquidation of direct investment** **10.Real Estate transactions** **11.Personal capital movements**[4] **12.Provisions specific to commercial banks and other credit institution** **13.Provision specific to institutional investors**

Remarks
1. This description does not reproduce AREAER book presentation. Hence in each period, slight changes can indeed be witnessed in the naming of categories, or the letter or numbers pointing to the line referring to those categories. Those changes are not mentioned here and we preferred putting numbers of our own for the presentation of this study.
2. The year indicates the one of the annual reports, but the actual practice of capital restrictions usually corresponds to December of the previous year. In the database some restrictions of the annual report of 1996 are therefore considered as year 1995 data.
3. Until 1985, "Prescription of currency" exists. Also from 1986, one more category "Payment Arrear" is created.
4. Starts from the 1998 report.

Some studies do not face such a problem because they deal only with one type of classification, either by creating a dummy variable from the summary table (Epstein, Gerald, Schor -1992-; Razin, Rose -1994-; Grilli, Milesi-Ferretti -1995-; Rose -1996-;

Johnston, Tamirisa -1998-) or by encoding the text description (Alesina, Grilli, Milesi-Ferretti -1994-; Quinn -1997-). Belonging to those studies we should mention the one of Rose (1996) which analyzes the trilemma issue. Written prior to the 1997 change, Rose uses factor analysis on several categories of restrictions to which he attributes a dummy variable, value 1 for existing restrictions and 0 for non-existing[3]. Rose acknowledges that the weakness of his study probably lies in his capital flows restriction index measurement although the values he obtained seem to match common sense. We might question whether or not the non-existence of the trilemma relationship that Rose finds stem from its capital index measurement. Related to this matter Eichegreen (2003) provides useful comments about the limits of the use of the 1968-1996 classification when calculating a capital restriction index.

Other studies dealing with period spreading on classification changes have all had to resolve these changes. They all somehow use the text description provided for each country to do so. A lot of studies deal with the connection between the two summary tables classification, whether they use only one category (Shambaugh -2004-; Obstfeld, Shambaugh, Taylor -2005-) or several of them (Brune, Garrett, Guisinger, Sorens -2001-; Miniane -2004-). In terms of text encoding Quinn's methodology (1997) has proven to be quite popular and is used by Obstfeld, Shambaugh, Taylor (2005) for classification extension. Miniane (2004) provides a methodology of backward induction (to year 1983) of the most recent 1997 capital restrictions classification by using the text and the section "change" in the AREAER book. This index has been used afterwards by Edwards (2007).

2. Methodology of calculation

In our capital flows restriction index calculation, the main contribution we bring is the use of a probit and logit econometric model for the matching of the 1968 and 1997 classifications. On the category choice prior to 1996, we follow several studies

[3] The categories from the summary tables used by Roses are the following ones: AREAR dummy variable on capital restrictions; AREAR dummy variables for bilateral payments restrictions to both IMF Members and Non Members; AREAR dummy variable for advance import restrictions; AREAR dummy variables for multiple exchange rate. To those categories he also adds the absolute value of the ratio of net exports to gross exports plus imports, and a linear time trend to reflect exogenous technological development.

(Shaumbaugh -2004-; Obstfeld, Shaumbaugh, Taylor -2005-; Klein, Olivei -2005-) by using only the capital restriction category called "Restriction exists on payments in respect of capital transactions"[4] and corresponding to line number 6 in *Table 4* of this article. The choice is justified by the difficulty of using other categories of restriction in the classification of 1968-1996. Most of those categories concern trade exchange, and even though one might be able to infer some kind of indirect role to those categories in terms of capital restrictions, the lack of direct connection might lead to wide bias, countries open to trade not necessarily practicing the same policy in terms of capital flows. Useful discussion is provided by Eichengreen (2003) on this matter, and although he also mentions the fact that "[Restriction exists on payments in respect of capital transactions] *refers exclusively to resident owned funds and may not reflect restrictions on capital transfer by non-resident*" it remains the most accurate direct measurement available for capital account restriction. Prior to 1996 we therefore use a dummy variable putting the value 1 when the restriction exists and 0 when it does not.

As *Table 4* shows, after 1996 the classification which was primarily based on trade exchange restrictions switches to a 13 categories classification, all dealing with capital flows restrictions. As in Shambaugh (2004) and Obstfeld, Shambaugh, Taylor (2005) we also try to summarize this information into one category, but unlike them and other studies which base their analysis on the encoding of the IMF text, we induce a function that allows us to determine, on a range of 0 to 1, how those thirteen categories could be summarized.

To create this function we assume that, at the time of change, between 1995 (meaning still the old classification started in 1968) and 1996 (new classification in the 1997 report) countries still had similar practice in terms of capital restrictions. Using probit and logit models we regress the dummy variable of 1995 (called Y) with the new 13 categories of 1996 as explanatory variables. The equation obtained gives us a function in which we can input for each following years (1997 to 2005) the 13 categories to calculate a probability between 0 and 1.

Practically we however face a problem of multicollinearity of the explanatory

[4]Change in the naming and numbering of this category in the AREAER book (year of publication) is as follows:
Restrictions exist on payments in respect of capital transactions 1970-1973 Line 11
Restrictions exist on payments in respect of capital transactions 1974-1980 Line 10
Restrictions on payments for capital transactions 1981-1996 line E2

variables, the 13 categories of restriction being too numerous. In order to solve this problem we use an intermediate stage by using principal factor analysis to "summarize" the explanatory variables into components. The details of the procedure to calculate the capital flows restriction index are explained in the *Appendix 2* of this article.

3. Comments about the CF index

Table 5 shows a general picture of the evolution of the capital flows restriction index over the years. If one looks at the average value one can see that the general trend concerning capital restrictions is one of decrease over the years. Overall therefore the

Table 5: CF index main values

	1970s	1980s	1990s	2000s	Panel
Average	1.25	1.13	0.92	0.74	1.00
Standard deviation	0.76	0.79	0.66	0.57	0.72
Maximum Value	1.76	1.76	1.76	1.58	1.76
Minimum Value	0.00	0.00	0.02	0.06	0.00

Table 6: CF index in the 1990s

Country	CF index in the 1990s	Country	CF index in the 1990s	Country	CF index in the 1990s
Panama	0.019	Peru	0.585	Croatia	1.569
Hong Kong	0.032	Indonesia	0.590	Bulgaria	1.575
Netherlands	0.032	Italy	0.607	Thailand	1.584
Canada	0.035	Portugal	0.608	Mexico	1.587
Denmark	0.041	Malaysia	0.633	Slovak Republic	1.634
UK	0.044	Ecuador	0.639	Brazil	1.644
New Zealand	0.049	France	0.679	Hungary	1.669
Switzerland	0.062	Sweden	0.705	China	1.674
Germany	0.065	Argentina	0.827	Poland	1.679
Singapore	0.116	Norway	0.968	Korea	1.680
US	0.117	Spain	1.009	Morocco	1.691
Belgium	0.209	Greece	1.110	Philippines	1.691
Japan	0.255	Venezuela	1.173	South Africa	1.691
Austria	0.258	Egypt	1.217	Chile	1.699
Australia	0.267	Nigeria	1.355	India	1.710
Finland	0.304	Czech Republic	1.440	Russia	1.710
Kuwait	0.315	Israel	1.502	Colombia	1.740
Saudi Arabia	0.353	Slovenia	1.506	Romania	1.763
Ireland	0.402	Turkey	1.558		

countries in this panel tend to have less and less restrictions over time. The standard deviation being nevertheless relatively high, one can assume a lot of variations from one country to another over the years.

As an illustration, we present briefly in *Table 6* the results of the calculations of the capital flows restriction index for the 1990s that we obtained after proceeding to the work described in the previous section. No striking results seem to come out of this chart. The countries that are the less restricted are two small very open economies (Panama and Hong Kong). By a rough look at the chart we can see that most of the industrialized countries are more at the top of the table (Netherlands, Canada, Denmark…). Greece, Spain, Norway, Sweden and France are the most restricted among them. Developing economies show a higher value for the CF index, the most restricted economies in the 1990s being India, Russia, Colombia and Romania.

IV. Econometric analysis of the trilemma: existence of a conditional trilemma

1. Tested Equations and results

We first test what we call the "non conditional" trilemma which means that we check whether the three variables MP, ER and CF are significantly related to each other without adding any extra explanatory variables to the equations. The tested fixed-effect equation takes the following form:

Non conditional trilemma:

$$ER_{it} = \alpha_i + \beta \ln MP_{it} + \mu CF_{it} + \sum_{t=2}^{4} \omega_t Year\_dummy_t + \sum_{i=1}^{n-1} \delta_i Country\_Dummy + \varepsilon_{it}$$

Where *i* denotes the countries, *t* the 4 periods of time of the panel (t=1:1970s, t=2:1980s, t=3:1990s and t=4:2000s) detailed in *Appendix 1*, and *n* the number of countries.

In order for trilemma to exist we are expecting the following signs:

- $\beta < 0$. This would show that as MP increases (the monetary policy is less independent) exchange rate volatility tends to stabilize. It illustrates the fact that giving up part of the monetary policy independence helps in stabilizing the exchange rate, like we have seen in the part of the dilemma analysis.
- $\mu < 0$. This would show that as CF increases (the country is more restricted in terms of capital flows) the exchange rate volatility tends to stabilize. Giving up capital flows freedom can therefore help in stabilizing the exchange rate.

Results of the check of the existence of the trilemma can be seen in *Table 7* in the first column entitled "Non conditional trilemma". As we can see, without adding any extra explanatory variables to the econometric equation we cannot prove the existence of a significant relationship between the three variables of the trilemma. One can see that only the variable MP shows a significant result with the expected negative sign. The variable CF, although displaying the expected negative sign, is not significant.

Facing such results, we could however reasonably think that the trilemma could exist provided some other explanatory variables are inserted in the tested equation, in which case we would obtain what we could name a conditional trilemma. The two extra explanatory variables we added to check the existence of such a trilemma, are the inflation rate and the current account. We believe that inflation and current account ought to be tested because they should improve the significance of CF and be related significantly to ER. For example countries undergoing high inflation and high current deficit can potentially be targeted for speculative attacks. In that scenario restriction on capital flows should affect significantly the exchange rate. For countries that liberalize capital flows they usually manage to perform well in lowering inflation and current account deficit which enhance the stability of the exchange rate.

These two extra variables added in the trilemma equation are described in *Appendix 3*. Adding those extra explanatory variables, we obtain the following equation to be tested:

Conditional trilemma

$$ER_{it} = \alpha_i + \beta \ln MP_{it} + \mu CF_{it} + \gamma \ln INF\_rate_{it} + \theta CA_{it} + \sum_{t=2}^{4} \omega_t Year\_dummy_t + \sum_{i=1}^{n-1} \delta_i Country\_Dummy + \varepsilon_{it}$$

For this conditional trilemma we are expecting to find $\gamma > 0$ (higher inflation countries have more problems stabilizing their exchange rate) and $\theta < 0$ (as the current account becomes more positive the exchange rate stabilizes).

Results of this new regression can be seen in the second column of *Table 7*. As we can see adding inflation (*Ln_Inf_rate*) and the current account (*CA_%_GDP*) makes the trilemma relationship become significant. The variable CF shows a negative and significant result.

Table 7: Conditional trilemma and dilemma

ER as dependent Variable				
Variables	1. Non Conditional **Trilemma**	2.Conditional **Trilemma**	3.Non Conditional **Dilemma**	4.Conditional **Dilemma**
LnMP	-0.491*** (0.173)	-0.511*** (0.151)	-0.502*** (0.168)	-0.519*** (0.149)
CF	-0.124 (0.104)	-0.217** (0.093)		
Ln_Inf_rate		0.693*** (0.239)		0.568** (0.235)
CA_%_GDP		-0.041*** (0.008)		-0.039*** (0.008)
Yeardummy 80s	0.152 (0.130)	0.080 (0.114)	0.191 (0.125)	0.154 (0.112)
Yeardummy 90s	-0.057 (0.144)	-0.091 (0.125)	0.016 (0.129)	0.032 (0.114)
Yeardummy 00s	-0.399** (0.158)	-0.191 (0.143)	-0.319** (0.143)	-0.080 (0.138)
Constant	1.173*** (0.184)	1.149*** (0.161)	0.998*** (0.107)	0.861*** (0.105)
R-Square				
Within	0.2931	0.4779	0.2906	0.4534
Between	0.1824	0.0853	0.2212	0.0877
Overall	0.1996	0.2126	0.2291	0.2131
The standard error value is in brackets sf=significance level *** sf<1% **1%<sf<5%* 5%<sf<10%				

Inflation and current account also display the expected results, and are both significant. One can therefore assert that although the trilemma relationship cannot be verified if one takes only the three variables ER, MP, CF, one can prove its existence provided some extra variables (Inflation and current account) are added to the equation. *Regressions 3* and *4* display the results for the dilemma as a comparison. One can see that the dilemma exists whether it is conditional or not, all the coefficients showing the

expected signs and being significant.

2. Further inquiry of the conditional trilemma

a. Robustness tests

Before commenting on the results of the conditional trilemma in more detail, we present some robustness tests we have carried out on its equation (*Regression 2 of Table 7*). In order to test whether this relationship is robust we have carried out two sets of regressions that can be seen in *Table 8*. The first set tests changes that we have made in the calculation of the capital flows restriction index. *Regression 1* is the same as the conditional trilemma regression of *Table 7* and is put here for comparison with the three others.

Regression 2 shows the results when a logit model is applied to the matching function between the two AREAER classifications when calculating the index CF. As expected, the results are almost identical, the two functions usually giving very similar results. *Regressions 3* and *4* show regressions when changes are applied in the principal component analysis stage of the CF index calculation. It is indeed theoretically speaking possible to take out 2 categories out of the new classification and carry out the principal component analysis only on 11 categories of restrictions instead of 13. The two categories taken out are the last two of *Table 4*, number 12 and 13. These categories are entitled "Provisions on…" and their definition in the AREAER book specifies that these types of provisions do not necessarily aim at controlling capital flows, even though the effect might be so[5]. Regression results using a CF index only with 11 categories of capital controls categories -probit and logit- show significant results with a slightly lower value for the coefficient of CF. Adjusting the method of calculation of CF by using less categories of capital control does not therefore alter our conclusion concerning the existence of a conditional trilemma.

[5] In the main analysis, considering 13 categories of restrictions we followed Miniane (2004). In his index he also takes the multiple exchange rate system categories but we preferred keeping only the categories entitled control or provision on capital.

Table 8: Further regressions on the trilemma equation

ER as dependent variables				
Change in CF calculations				
Variable	1.CF_probit_13cat	2.CF_logit_13cat	3.CF_probit_11cat	4.CF_logit_11cat
LnMP	-0.511***	-0.510***	-0.514***	-0.514***
	(0.151)	(0.151)	(0.146)	(0.146)
CF	-0.217**	-0.216**	-0.215**	-0.214**
	(0.093)	(0.092)	(0.090)	(0.090)
Ln_Inf_rate	0.693***	0.691***	0.697***	0.696***
	(0.239)	(0.239)	(0.236)	(0.236)
CA_%_GDP	-0.041***	-0.041***	-0.041***	-0.041***
	(0.008)	(0.008)	(0.008)	(0.008)
Yeardummy 80s	0.080	0.081	0.081	0.081
	(0.114)	(0.114)	(0.113)	(0.113)
Yeardummy 90s	-0.091	-0.090	-0.088	-0.087
	(0.125)	(0.125)	(0.122)	(0.122)
Yeardummy 00s	-0.191	-0.190	-0.183	-0.184
	(0.143)	(0.143)	(0.141)	(0.141)
Constant	1.149***	1.147***	1.141***	1.140***
	(0.161)	(0.161)	(0.156)	(0.156)
R square				
Within	0.4779	0.4777	0.4843	0.4841
Between	0.0853	0.0856	0.0671	0.0675
Overall	0.2126	0.2128	0.2124	0.2125
Addition of variables to the main equation				
Variables	5	6	7	8
LnMP	-0.514***	-0.478***	-0.495***	-0.521***
	(0.153)	(0.152)	(0.155)	(0.163)
CF	-0.185*	-0.213**	-0.228**	-0.217**
	(0.095)	(0.092)	(0.095)	(0.101)
Ln_Inf_rate	0.698***	0.662***	0.679***	0.668**
	(0.240)	(0.239)	(0.241)	(0.269)
CA_%_GDP	-0.052***	-0.045***	-0.043***	-0.037***
	(0.011)	(0.008)	(0.008)	(0.010)
Openness	0.231			
	(0.231)			
Ln_GDP_per_Cap		0.0343		
		(0.247)		
Ln_GDP			0.132	
			(0.259)	
Deficit_%_GDP				-0.014
				(0.016)
Yeardummy 80s	0.091	0.011	0.034	0.055
	(0.120)	(0.124)	(0.146)	(0.122)
Yeardummy 90s	-0.101	-0.238	-0.187	-0.081
	(0.148)	(0.163)	(0.226)	(0.134)
Yeardummy 00s	-0.190	-0.373*	-0.315	-0.165
	(0.183)	(0.194)	(0.283)	(0.161)
Constant	0.934***	-1.733	2.166	1.119***
	(0.209)	(2.080)	(6.480)	(0.178)
R-Square				
Within	0.4865	0.4885	0.4793	0.4622
Between	0.0445	0.1096	0.0298	0.0869
Overall	0.2336	0.0011	0.1227	0.1949

The standard error value is in brackets
sf=significance level *** sf<1% **1%<sf<5%* 5%<sf<10%

The second set of robustness tests consists of the addition of other explanatory variables[6] (*Openness, GDP per capita, GDP* and *Deficit*). None of the variables display any significance in the equation and they do not affect the significance of the conditional trilemma found previously. The most disturbing explanatory variable is *Openness* which affects CF index but still remains significant. The *Openness* variable being related to capital flows freedom, this result is easily understandable, but also shows that our conditional trilemma result is very robust. We shall now interpret the meaning of the results we found.

b. Analysis and interpretation of the conditional trilemma

Fundamentally, when studying the trilemma constraint, what we would like to understand is why certain countries are able to have a less binding constraint, that is to say, perform better in the way of coping with the trilemma. This problem is fundamental in the sense that a weaker constraint means being able to achieve a little bit of everything better in terms of macroeconomic policy, stabilizing exchange rate more effectively, having a more independent monetary policy to cope with domestic macroeconomic problems such as inflation or unemployment, freeing capital flows more and having a more prosperous trade. What our results in *Table 7 Regression 2* show us is that first of all, the trilemma constraint exists only when other variables (inflation and current account) are taken into account and that those variables account for the way countries perform toward the trilemma, i.e. the way the constraint will exert itself on countries. In that regard, an interesting parallel can be drawn with the conditional convergence found by Barro and Sala-i-Martin in growth theory. In the case of growth models, catching up with other countries in terms of growth can only occur if certain conditions are fulfilled by countries. Here also we could assert that the trilemma is conditional and that the performance of countries depends on other variables of the economy. Had the non-conditional trilemma existed, the performance measurement would have been the distance separating the origin of a three dimensional graph to the plane formed by the three variables ER, MP, and CF. (since the value 0 of the three indexes is a non-reachable ideal state of

[6] For the calculation and sources of these new variables see *Appendix 3*.

perfect exchange rate stability, perfect monetary policy independence and perfect freedom of capital flows). In the case of the conditional trilemma the performance can be illustrated as follows:

$$\underbrace{ER - \beta lnMP - \mu CF}_{\text{Trilemma constraint}} = \underbrace{\gamma lnINF_{rate} + \theta CA + Fixed\_effect}_{\text{Performance value}}$$

This is a simplified form of the equation of the conditional trilemma. The left hand-side shows the trilemma constraint, i.e. the sacrifice due to the effort put on ER stability compromising with certain values of MP and CF. Since the left hand-side represents the trilemma the right part, which is equal to it, will stand for a performance value that countries have managed to achieve. The lower this value becomes the better the performance. Here the conditionality characteristics appear clearly: on one hand better inflation rate and current account help in lessening the bind of the trilemma constraint, but on the other hand countries' different characteristics included in the fixed-effect also play a significant part in the achievement of a good performance value. Some unexplained factors representing the "individuality" of each country (size, population, structure of the economy…) can account for this fixed-effect.

As a conclusion to this analysis we can therefore summarize our results as follows: the well known dilemma constraint stemming from the choice between monetary policy independence and exchange rate stability is non-conditional, it is a binding economic choice that no other economic variables influence. For the trilemma relationship however, we found its existence but only under certain conditions that remain to be explained.

V. Performance of countries under the trilemma constraint

In this section we would like to provide some descriptive statistics of the performance measurement that we introduced in the analysis of the conditional trilemma. We follow the formula introduced in the previous section, defining the trilemma performance as the sum of the predicted value of the inflation rate plus the

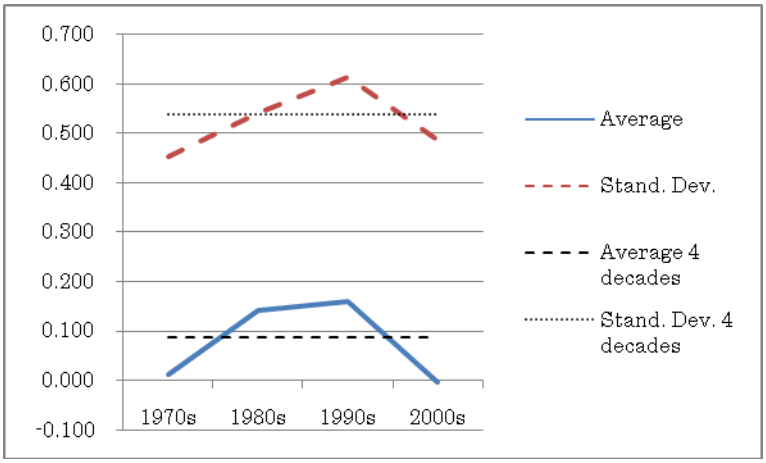
current account plus the fixed-effect of the country[7].

Details of the trilemma performance values per decade for each country can be seen in *Appendix 4* of this article. Since the number of observations differ from one decade to another, either because of the lack of data, or for the forth decade because of the creation of the Euro zone, it is difficult to interpret the data as it is. One can sense at first glance that industrialized countries, especially European countries (Germany, Netherlands, Belgium, Ireland,…) are performing very well, whereas developing countries are usually in the end of the chart (South Africa, Argentina, Nigeria,…) together with the Russian transitional economy for the last two decades. In order to get a more synthetic picture of the trilemma performance figures we provide some general trend from *Tables 9 to 12 and Graphs 3 to 7.*

Table 9: Summary statistics of performance values per decade

	1970s	1980s	1990s	2000s	Total 4 decades
nb of obs	26	35	53	43	157
Average	0.013	0.142	0.161	-0.004	0.087
Stand. Dev.	0.453	0.541	0.615	0.486	0.540
Max	1.300	1.985	2.074	1.045	2.074
Min	-0.631	-0.698	-0.686	-0.878	-0.878

Graph 3: Trilemma performance over the 4 decades



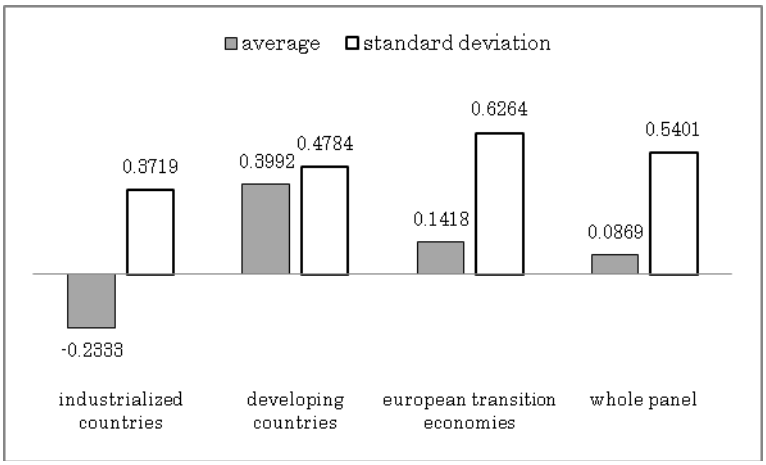
[7] To calculate the fixed-effect we used the function included in Stata. See Stata *Cross-sectional Time-Series Reference Manual Release 8*, p192 (1985-2003) Stata Press.

Table 9 and Graph 3 present the average and the standard value of the trilemma performance over the years. The curve of the mean value of the trilemma performance shows a bell shape. The lower the value of the trilemma performance figure the better the countries perform. This graph shows us that, regarding the trilemma constraint, countries were better off in the 1970s and the 2000s than the 1980s and 1990s. If one looks at *Table 10 and Graph 4* one can see that the performance figures vary according to the development level of the countries. Industrialized countries manage to achieve a much lower score than developing economies, the European transition economies scoring in between these two groups.

Table 10: Summary statistics of performance values per country level of development

	nb of obs	average	standard deviation
industrialized countries	71	-0.2333	0.3719
developing countries	70	0.3992	0.4784
european transition economies	16	0.1418	0.6264
whole panel	157	0.0869	0.5401

Graph 4: Comparison of trilemma performance for different type of development level



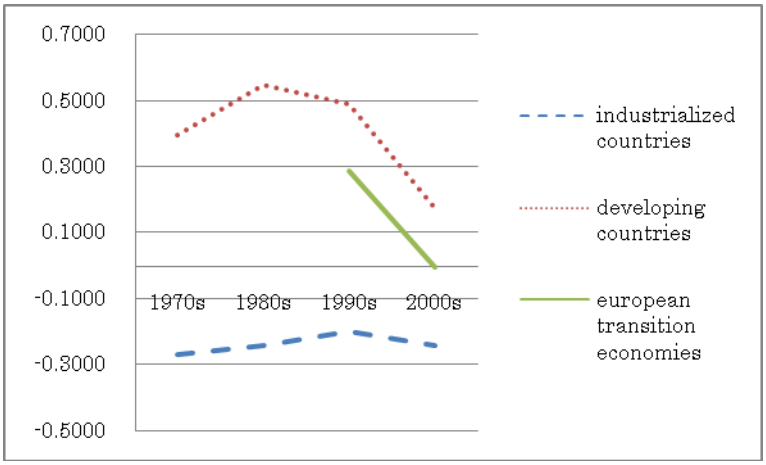
The important result of this graph is that, regarding the trilemma constraint, developed economies manage to be better off than the developing economies. This result can be seen in more detail on *Table 11* and *Graph 5*, which present a coupled view of *Tables 9-10* and *Graph 3-4*, both development level of countries and time being taken into account. Here one can see that developed economies have a pretty

constant level in their score of the trilemma performance whereas developing economies scores vary more, improving their performance after the 1980s. European transition economies also follow an improving trend from the 1990s to the 2000s. Although developed economies display a fairly stable score for the trilemma performance, one can notice an increase in the standard deviation over the years, illustrating the fact that, even among industrialized economies, one can observe a wide range of trilemma performance. Developed economies on the contrary display a high stable standard deviation level.

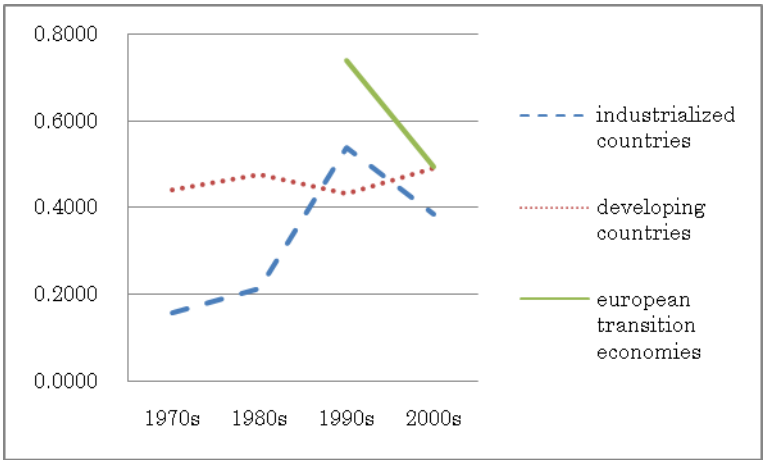
Table 11: Summary statistics of performance values per country level of development over years

Mean	1970s	1980s	1990s	2000s
industrialized countries	-0.2688	-0.2424	-0.1986	-0.2400
developing countries	0.3963	0.5492	0.4901	0.1733
european transition economies			0.2866	-0.0031
St.dev.	1970s	1980s	1990s	2000s
industrialized countries	0.1597	0.2168	0.5390	0.3861
developing countries	0.4428	0.4785	0.4335	0.4940
european transition economies			0.7396	0.4958

Graph 5: Trilemma performance level per decade and per level of development / Mean



Graph 6: Trilemma performance level per decade and per level of development / Standard deviation

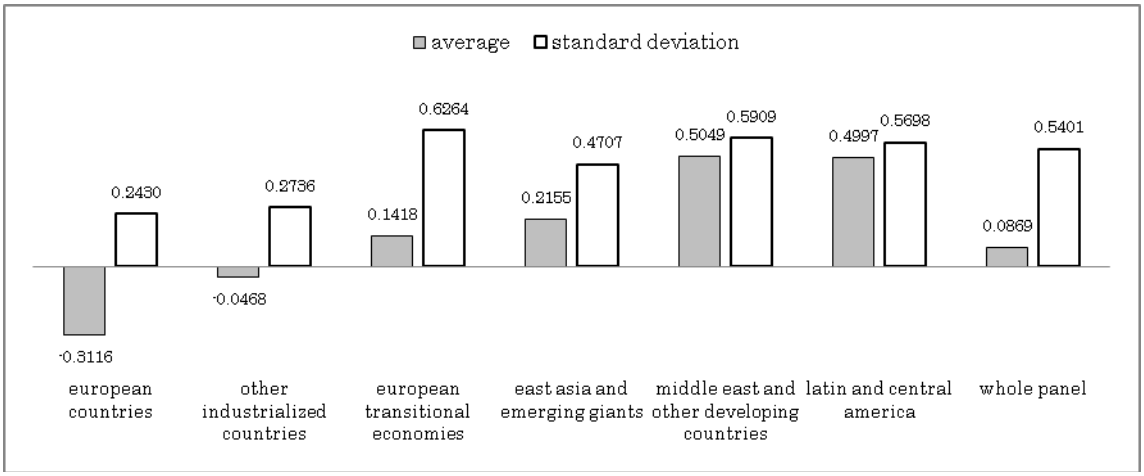


Finally, in *Table 12 and Graph 7* we try to present the level of trilemma performance according to some regional grouping (the detailed list of the groups can be seen on *Graph 9*) and countries' similarities. This chart shows us that European countries are the best performers, followed by a group of other industrialized economies. European transition economies and East Asia (plus India and China) have medium scores, while the last two groups representing Latin American countries and other developing economies (with Middle East) are the worst scorers regarding the trilemma performance.

Table 12: Summary statistics of performance values per type of countries

	average	standard deviation
european countries	-0.3116	0.2430
other industrialized countries	-0.0468	0.2736
european transitional economies	0.1418	0.6264
east asia and emerging giants	0.2155	0.4707
middle east and other developing countries	0.5049	0.5909
latin and central america	0.4997	0.5698
whole panel	0.0869	0.5401

Graph 7: Trilemma performance / some countries grouping



VI. Choice of countries under the trilemma constraint

Having proved the existence of a conditional trilemma we would like, in this section, to provide some inquiries about the tradeoff that countries have adopted concerning the choice of their trilemma policy. We will therefore focus on the policy-mix aspect (or tradeoff) occurring in the trilemma, meaning that we are interested in how much each country devotes to each variable. In order to achieve this goal we create a graph in the shape of *Mundell's triangle of incompatibility* enabling us to see positions of countries relative to the vertices representing the three variables ER, MP and CF. Explanations of the derivation of this graphic are detailed in the first part of this section and *Appendix 5*. In the second part we comment on our results and put them into perspective with the scheme provided in the introduction of this article.

1. The graph derivation

We summarize the basic principle of the analytic tool we provide here but for the details of the derivation of the graph the reader should refer to *Appendix 5* of this article. The basic idea of this triangle graph is to express the position of countries of a three dimensional graph into a two dimensional triangle graph (representing the trilemma) where the distances to the vertices are in terms of percentage (illustrating how much sacrifice is made in terms of one aspect of the trilemma). Proceeding to

such an analysis implies two main assumptions: first we assume that the trilemma relationship conditions are set and that we can observe the trilemma in a three dimensional graph, second we assume that countries are facing the same slope. We allow only the distance to the origin of the three dimensional graph to differ from one country to another (*See Appendix 5 Graph 1*). Looking at the vertices of Mundell's triangle originating from this three dimensional graph we can see here why we privileged the representation that shows the vertices as the "undesirable" goals (Frankell -1999-, Benassy-Quéré, Coeuré, Jacquet, Pisany-Ferry -2004-) rather than the one featuring the vertices as the desirable goals (Karem -2005-, Krugman, Obstfeld -2006).

The policy-mix in terms of percentage can be expressed as follows:

$$MP\%_i = \frac{x_{MPi}}{x_{MPi} + y_{ERi} + z_{CFi}} \qquad (1)$$

$$ER\%_i = \frac{y_{ERi}}{x_{MPi} + y_{ERi} + z_{CFi}} \qquad (2)$$

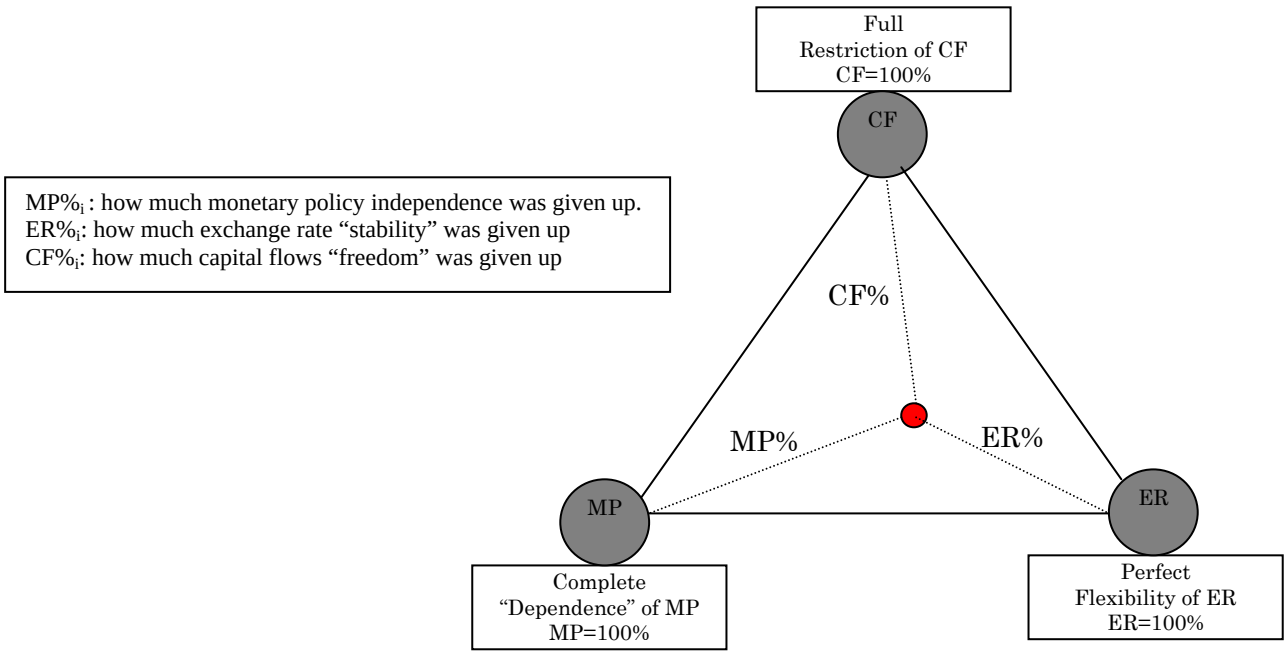
$$CF\%_i = \frac{z_{CFi}}{x_{MPi} + y_{ERi} + z_{CFi}} \qquad (3)$$

$$MP\%i + ER\%i + CF\%i = 1 \qquad (4)$$

with $x_{MPi}, y_{ERi}, z_{CFi}$ standing for the coordinates of the indices in the three dimensional graph. $MP\%_{i,}$ is the share represented by the monetary policy independence index in the sum of the three indices for country *i*, or in other words how much monetary policy independence this country *i* gave up. For example, if MP%=100% it means that ER%=0 and CF%=0, that is to say, country *i* is completely stable in terms of exchange rate (definition of the index ER) and completely free in terms of capital flows (definition of CF index). If that is the case, it means that country *i* gave up 100% of its monetary policy independence or has a completely "dependent" monetary policy. Applying the same reasoning $ER\%_i$ is the percentage

of "stability" that was given up and $CF\%_i$ the percentage capital flows freedom that was given up. The triangle graph is read as shown in *Scheme 2*[8].

Scheme 2: The trilemma tradeoff

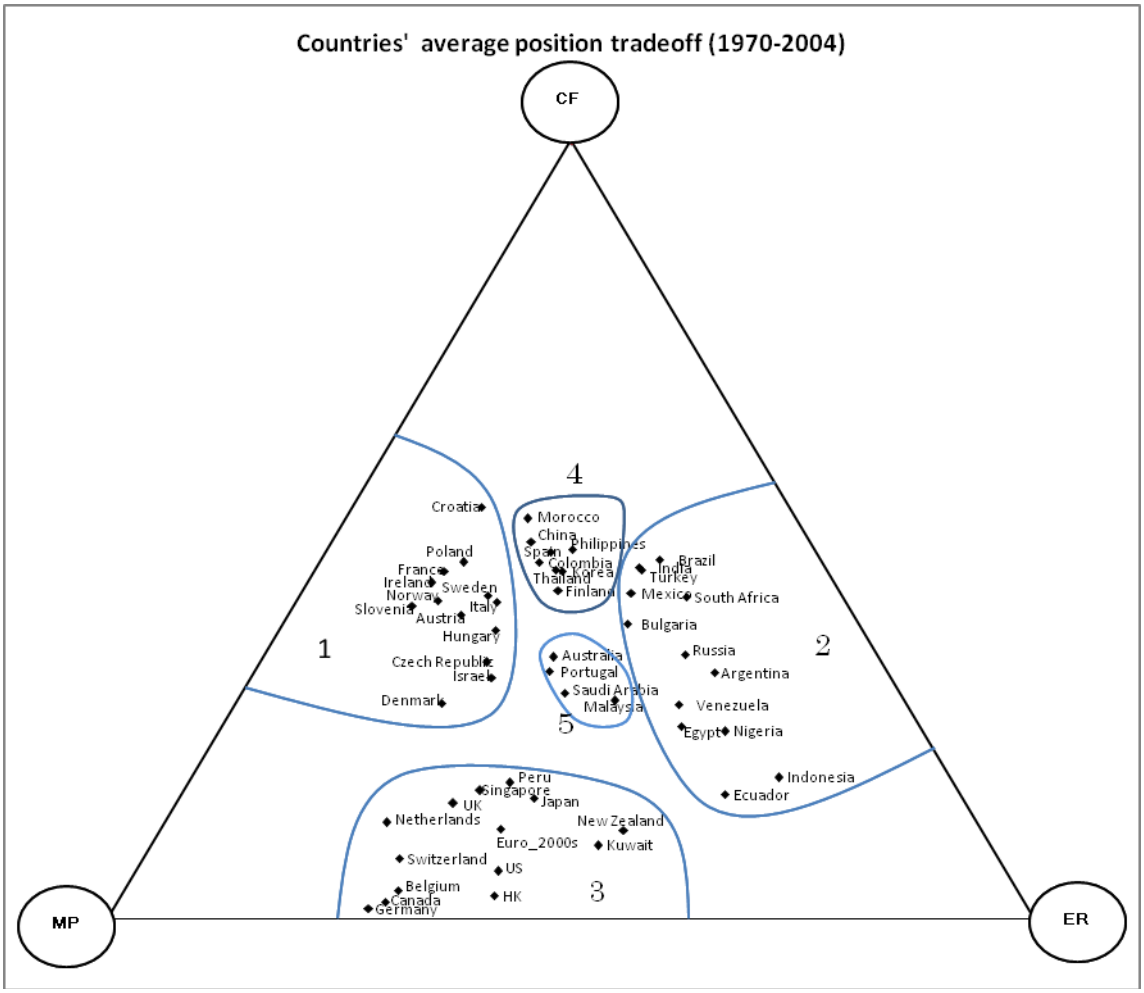


2. Countries' position over the panel period

The triangle in *Graph 8* shows us the results of the calculation presented in the previous section. The position of the countries is the average position over the 4 decades of the panel. We have divided the countries into 5 groups: 3 wide ones each leaning toward one of the side of the triangle (1, 2 and 3), and 2 smaller groups in the center of the triangle (4 and 5), one of them being positioned a little more toward the vertex CF. What this benchmark triangle graph shows in terms of countries' positioning is of great interest. First of all, one can see that there are no tendencies for countries to go clearly toward one vertex. The groups 1, 2, and 3 are on the contrary showing us a position that could be summarized as three dilemmas. Indeed,

[8] Here we would like to warn the reader that a shorter distance from an vertex means a higher percentage of "giving up" one of the variables. If a country is located on the vertex MP then it means that it gave up 100% of its monetary policy independence.

Graph 8: Triangle graph



Country Name	MP%	ER%	CF%	Country Name	MP%	ER%	CF%	Country Name	MP%	ER%	CF%
Argentina	18.7	49.7	31.6	Malaysia	31.2	40.7	28.1	Philippines	26.1	26.5	47.4
Australia	35.1	31.2	33.7	Mexico	22.6	35.5	41.9	Poland	38.6	15.5	45.9
Austria	42.3	18.6	39.1	Morocco	29.0	19.6	51.4	Portugal	36.5	31.8	31.7
Belgium	66.7	29.6	3.6	Netherlands	63.7	23.9	12.5	Russia	20.7	45.3	33.9
Brazil	17.4	36.4	46.1	New Zealand	38.7	49.9	11.4	Saudi Arabia	36.2	34.9	29.0
Bulgaria	24.9	37.2	37.9	Nigeria	21.4	54.5	24.1	Singapore	51.6	31.9	16.6
Canada	68.8	28.9	2.2	Norway	43.9	15.2	40.9	Slovenia	47.1	12.7	40.2
China	30.1	21.5	48.4	Peru	47.8	34.6	17.6	South Africa	16.9	41.7	41.3
Colombia	30.6	23.7	45.7	Hungary	39.6	23.4	37.1	Spain	28.6	24.3	47.1
Croatia	33.3	13.9	52.8	India	20.1	34.8	45.1	Sweden	38.2	20.3	41.5
Czech Republic	42.6	24.4	33.0	Indonesia	18.5	63.3	18.2	Switzerland	64.6	27.6	7.8
Denmark	50.1	22.2	27.6	Ireland	43.4	13.3	43.2	Thailand	29.3	26.0	44.8
Ecuador	25.4	58.6	16.0	Israel	43.1	25.9	31.0	Turkey	20.0	35.2	44.7
Egypt	25.8	49.5	24.7	Italy	37.6	21.7	40.6	UK	55.3	29.8	14.9
Finland	30.4	27.5	42.1	Japan	46.2	38.3	15.5	US	54.7	39.1	6.2
France	41.4	14.0	44.6	Korea	28.6	26.7	44.7	Venezuela	24.6	47.8	27.5
Germany	71.2	27.5	1.3	Kuwait	42.4	48.1	9.5	Euro_2000s	51.7	36.7	11.6
Hong Kong	56.7	40.2	3.1								

Remark:

- Only countries that have at least two observations in the 4 periods panel appear on the graph
- For European countries, average is on the first 3 decades, then Euro_2000s stands for the latest period

each of these groups is quite markedly far from at least one vertex, which illustrates the fact that countries belonging to those groups tend to have a clear-cut position at least for one variable of the trilemma, but that they have a medium position concerning the two other variables. Hence countries belonging to group 1 have a policy-choice emphasizing stabilization of exchange rate volatility (because they are far from ER vertex they reject exchange rate volatility). This group is composed, except for Israel, only of European countries. One can find some northern European countries (Norway, Sweden, Denmark) as well as most of the Eastern European countries (Hungary, Czech Republic, Slovenia, Poland, Croatia). Four of the Euro zone countries (France, Italy, Austria, Ireland) can also be seen. This group faces a dilemma between capital flows freedom and independence of monetary policy, and countries tend to be positioned rather in the middle of the axis MP-CF. It means that their choice was to give up some of their monetary policy independence as well as some of their capital flows freedom in order to concentrate on fixing the exchange rate. Group 2, on the contrary, could be defined as a group far from the vertex MP, which means that countries belonging to this group value independence of monetary policy. The composition of this group is quite eclectic geographically speaking (South America, Africa, Middle East, Transitional Economies of Europe) but gathers mainly developing countries. The emphasis put on monetary policy independence can be interpreted as a need for these countries to be able to freely deal with recurrent domestic economic challenges in macroeconomic stabilization. Having chosen independence of their monetary policy as their main need, those countries face a dilemma between capital flows freedom and exchange rate flexibility, shown by their position along the axis CF-ER. The countries' spread along CF-ER is wider than group 1, Brazil, India or Turkey for example favoring rather exchange rate stability and therefore emphasizing more on capital restriction. On the contrary, in the same group Indonesia and Ecuador can be seen as choosing rather exchange rate flexibility in order to be able to keep capital flows freedom. Group number 3 can be defined as the one favoring freedom of capital, and facing a dilemma between monetary policy independence and exchange rate volatility. This group encompasses mainly industrialized countries, European as well as non-European. These countries are located far from the CF vertex and are therefore emphasizing freedom of capital

flows in their trilemma policy mix. Along the MP-ER axis one can notice a slight positioning more toward MP, which means that effort put on stabilizing the exchange rate is seen as an important task, even at the cost of monetary policy independence loss. This positioning, except for Canada, occurs rather for European countries (Netherlands, Germany, Belgium, Switzerland), the other industrialized countries like Japan, New Zealand, or the US being slightly more in the middle of the MP-ER axis.

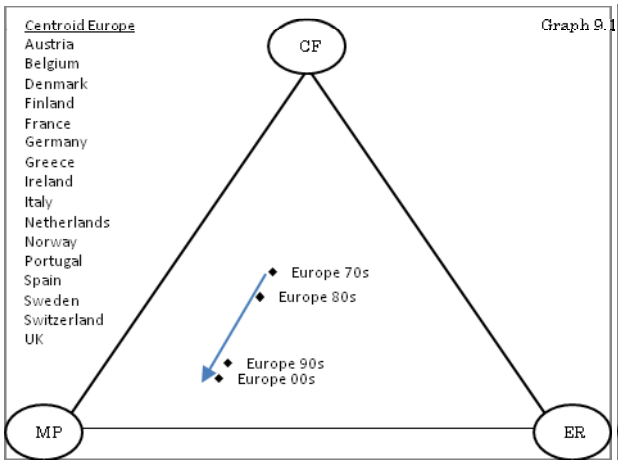
Groups 4 and 5 having a more central position on the graph their positioning seems more difficult to interpret. One could however say that group 4 represents countries emphasizing slightly more capital flows restriction in their trilemma policy-mix. It would therefore mean that those countries favor capital flows restriction in order to be able to achieve the simultaneous goal of having a stable exchange rate and an independent monetary policy. Group 5 is positioned lower and almost in the center of the triangle, the countries belonging to it splitting almost evenly the percentage devoted to each variables of the trilemma. Here one should stress the fact that such a positioning might be related to a trilemma policy-mix change during the 4 decades of our panel, which is therefore reflected in the averaging of the whole period of the panel.

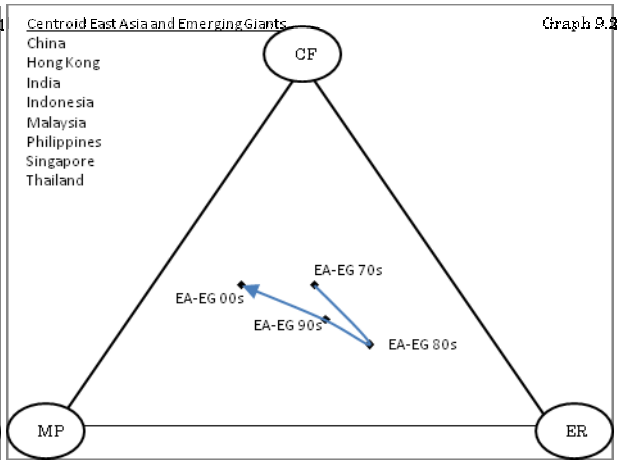
Some interesting features can be drawn from this approach concerning the choice made by countries regarding the trilemma. It seems that the most common reasoning for countries' government is first to give priority to one of the variable of the trilemma in its positive acceptation, i.e. fixing the exchange rate, running an independent monetary policy, or freeing capital flows. In a second time, facing a dilemma between the two other variables, countries adopt different positioning along the main goal's opposite axis of the triangle.

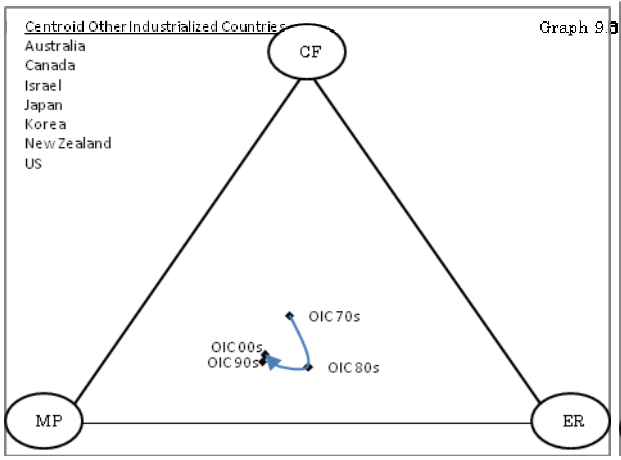
3. Evolution of countries' position over time

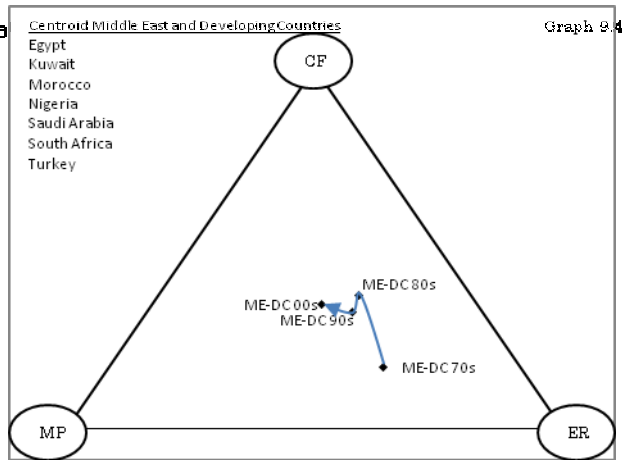
In *Graph 9* we present a series of graphics showing some dynamic evolution of the trilemma policy-mix. The first 6 graphics (from *Graphs 9.1 to 9.6*) present evolution per decade per geographical region and/or type of countries (names of the

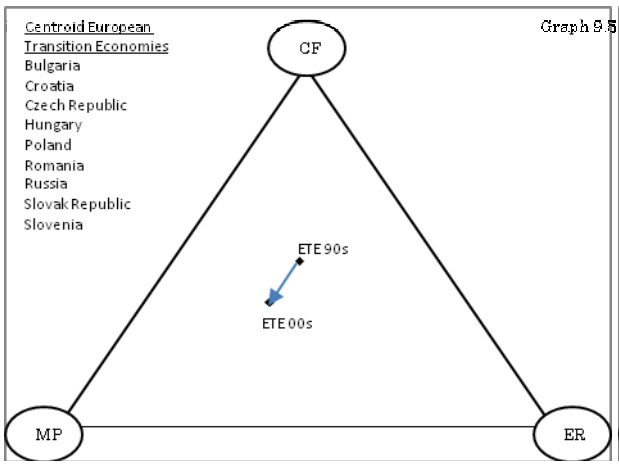
Graph 9: Evolution of the trilemma tradeoff over years

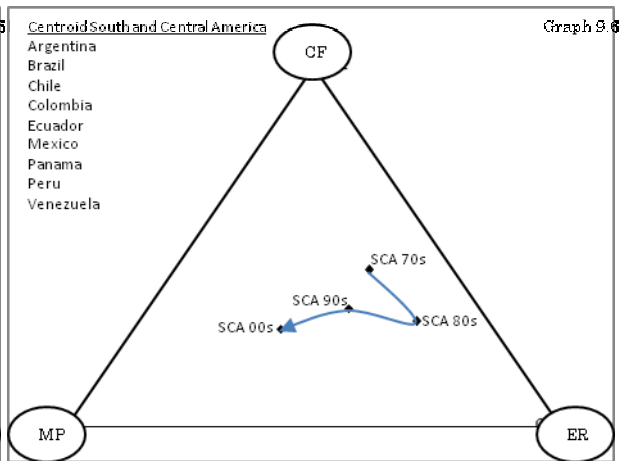


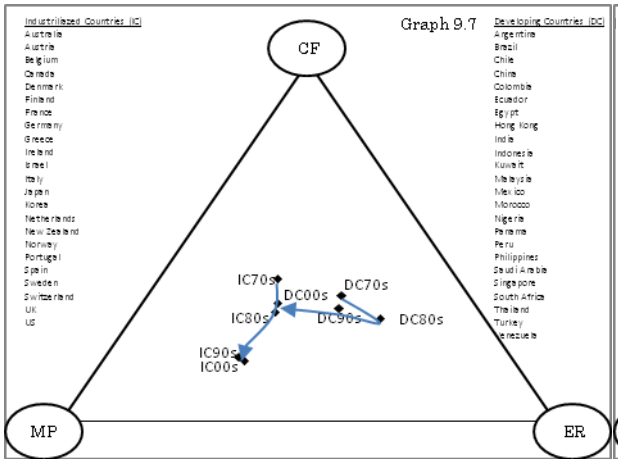


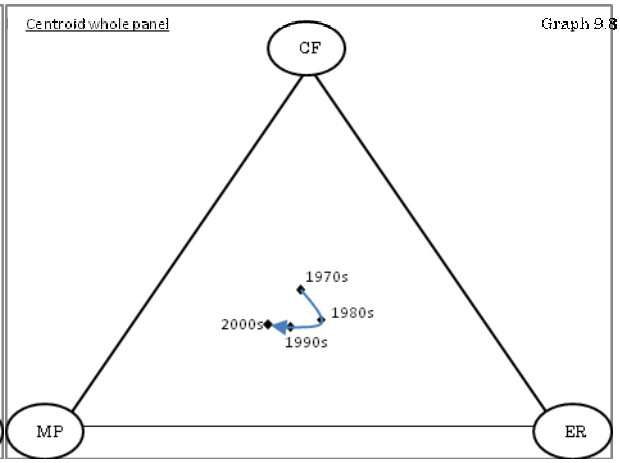












countries belonging to each group can be seen next to each graph). In the last two graphics we compare the evolution per type of country (Industrialized versus Developing countries, see *Graph 9.7*) and per decade for the whole panel (*Graph 9.8*). Concerning the first 6 graphics, it seems that there is a general trend, over the four decades, to emphasize more on the exchange rate stability in the trilemma policy-mix. *Graph 9.1* shows changes that occurred in Europe, with a very clear evolution. Europe has constantly valued stability of exchange rate and progressively diminished the weight granted to capital flows restriction in the trilemma policy-mix, and this at the expense of monetary policy independence. *Graph 9.5* representing European transition economies, although only on two periods, shows a similar trend. The positioning of those countries still remains higher on the capital flows restriction aspect of the policy-mix. On *Graph 9.3* can be seen the *Other Industrialized Countries* which display a curve going on the right in the 1980s and left in the next two decades. The period of the 1980s is marked by the financial deregulation where countries were emphasizing more independence of monetary policy (to solve domestic issues like unemployment and inflation) and freedom of capital flows, which translated into a choice of relatively more flexible exchange rates. This trend can also be seen on *Graphs 9.2* and *9.6* for other parts of the world. On *Graph 9.3*, again for the group *Other Industrialized Countries*, the last two periods of the panel are marked by a return to more emphasis on exchange rate stability with a loss of monetary policy independence but an approximately equal level of capital flows freedom in the policy-mix. *Graph 9.2, 9.4* and *9.6* on which developing countries are plotted show some wider movement in the policy-mix change over the panel period. Centroid of *East Asia and Emerging Giants* on *Graph 9.2* can be divided into two stages: starting in the 1970s around the center of the triangle a relatively sharp evolution toward more independence of the monetary policy and freedom of capital can be observed in the 1980s, this movement being done by putting less emphasis on stabilizing the exchange rate in the policy-mix. After the 1980s however the trend has changed in the opposite direction: efforts are put on stabilizing the exchange rate in the 1990s and 2000s, together with a slight reinforcement of the share granted to capital restriction. *Graph 9.6*, displaying South and Central American countries' path in the trilemma policy-mix, shows a similar trend, although this path is located more on the right of the triangle for the first two decades (more independence of the monetary policy), and that more emphasis is put on capital flows freedom for the last decade than

the countries in *Graph 9.2*. On *Graph 9.4,* showing some other developing countries one can see the 1970s and 1980s as a period with emphasis on independence of monetary policy, while there is a general trend of putting more weight on exchange rate stability in the last two decades.

It is possible to get an even more global picture of countries' trilemma tradeoff evolution by looking at *Graph 9.7* on which we have split the panel between industrialized countries and developing countries. For industrialized countries, the trend during the panel period is to keep a high share on stabilization of exchange rate (industrialized countries maintained overall the same distance to the ER vertex) while putting more and more weight on freeing capital. This general trend is made at the cost of independence of monetary policy in the tradeoff, industrialized countries getting closer to the vertex MP (less independence of monetary policy). Developing countries follow a two-stage path: from the 1970s to the 1980s the policy-mix tends to focus on independence of monetary policy and a relative freedom of capital flows at the expense of exchange rate stability. However the tendency post 1980s is to reinforce the role of exchange rate stabilization in the tradeoff. Unlike industrialized countries, which have maintained a pretty equal share devoted to exchange rate stability while diminishing monetary policy independence importance and emphasizing capital flows freedom in the tradeoff, developed countries have reinforced the stabilization of exchange rate by a combined loss of monetary policy independence and slight increase in capital flows restriction. On *Graph 9.8*, although the centroid of the whole panel does not show very wide movement and is positioned relatively in the middle of the triangle (due to the averaging of countries having opposite positions), a similar movement (although not as wide) as described in *Graph 9.7* for developing countries can be observed.

VIII. Conlcusion: policy implication and further research

Throughout our inquiry of the trilemma phenomenon we have managed to find several interesting results. First of all, we have found that the trilemma constraint exists, although it is a conditional trilemma. The relationship of the trilemma is indeed valid provided some other variables (inflation, current account) are taken into account in the estimated equation. Although confirmation of the existence of a conditional trilemma should still be inquired, we believe that the trilemma is a valid framework to consider when implementing macroeconomic policies.

Other areas of research that the trilemma field opens are related to the difference in countries performance toward the trilemma constraint. As we have shown, some countries manage to cope better than others when facing this trilemma constraint. In other words although the trilemma relation also constrained them, certain countries manage to achieve better results at the same time for the three variables (ER, MP, CF) than others. Further research in the trilemma field should be to understand what the determinants are for a better performance.

Concerning the choice made by countries regarding the trilemma tradeoff we have found results making us incline to believe that countries do not go to the vertices of the trilemma triangle but rather choose a side of it. This means that the trilemma is split into three dilemmas, depending on which of the three variables countries focus on. Here too, as for the performance value, finding the determinants of preferences of countries regarding the trilemma policy-mix should be considered as a topic for further research.

Once further research provides firmer ground to the existence of the trilemma, performance, preferences, and optimal response of monetary policy should all be part of a deeper inquiry of what could be called “trilemma economics”. Countries, when settling a monetary policy or choosing an exchange rate should therefore consider also the importance of the capital flows restriction. In that regard considering the trilemma framework to settle monetary policy induces some institutional consequences of coordination between central bank and authorities responsible for the setting of capital flows restriction. Overall governments and monetary authorities should be all the more conscious of this trilemma problem in today’s greatly globalized market. If talks of a new monetary order take place, lessons from the past crises, which were caused by the neglect of the trilemma theorem, should be carefully weighed and taken into account.

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APPENDIX 1: Source and details for the indices ER and MP

For ER

Source
JP Morgan real broad effective exchange rate indices (monthly data)
http://www2.jpmorgan.com/MarketDataInd/Forex/currIndex.html

Definition of the index
Standard deviation of the logarithm of the data per period for one country divided by the average standard deviation of the whole panel.

Mathematical formula

$$ER_{it} = \frac{\sigma_{it}(\ln REER_{im})}{\overline{\sigma(\ln REER)}}$$

ER_{it}: Exchange Rate volatility index in period t
$(\ln REER_{im})$ Logarithm of the monthly Real Effective Exchange Rate for country i
$\sigma_{it}(\ln REER_{im})$: standard deviation of $(\ln REER_{im})$ for country i in period t
$\overline{\sigma(\ln REER)}$: average of $\sigma_{im}(\ln REER_{im})$ for the whole panel

Definition of period t
t1=1970s: jan1970-dec1979
t2=1980s: jan1980-dec1989
t3=1990s: jan1990-dec1999
t4=2000s: jan2000-aug2004

Remark:
Euro zone does not include Luxembourg in this panel

Interpretation of the index
The closer to 0 the more stable the exchange rate is.

For MP

Source
IFS CD-Rom July 2006
All countries Line 60B MONEY MARKET RATE, CALL MONEY RATE
Except for missing reason
Ecuador 24860P..ZF...LENDING RATE
Nigeria 69460C..ZF...TREASURY BILL RATE
Norway 14260ZB.ZF…3 MONTHS FORWARD RATE ($)
Peru 29360P…ZF...LENDING RATE
Saudi Arabia 45660L…ZF…DEPOSIT RATE
China 92460P...ZF...LENDING RATE
Egypt 46960P...ZF...LENDING RATE
Hungary 94460P...ZF...LENDING RATE
Israel 43660P...ZF...OVERALL COST OF UNINDEXED CREDIT
Romania 96860C...ZF...TREASURY BILL RATE (91 DAYS)

Definition of the index
Correlation of country i monthly interest rate with a basket of the average interest rate of 4 main countries plus the value 1 normalized the mean of the panel.

Mathematical formula

$$MP_{it} = \frac{(\rho_{it} + 1)}{\overline{\rho_{it} + 1}}$$

$(\rho_{it} + 1)$ coefficient of correlation of country i with the basket "World Interest" (WI) in period a
$\overline{(\rho_{it} + 1)}$ average value of $(\rho_{it} + 1)$ for the whole panel

Definition of the basket WI
Average interest rate of Germany (Europe for the last period), Japan, UK and the US. To avoid biais while caculating the index of the countries belonging to the basket the correlation coefficient has been taken against the mean of the three other countries of the basket.

Definition of period t
t1=1970s: jan1970-dec1979
t2=1980s: jan1980-dec1989
t3=1990s: jan1990-dec1999
t4=2000s: jan2000-dec2005

Interpretation of the index
The closer to 0 the more independent the monetary policy is.

APPENDIX 2: Derivation of the probit-logit function to calculate the index CF

(Source of the capital flows restriction index: Annual Report on Exchange Arrangements and Exchange Restrictions 1971-2006, IMF)

First we proceed to the principal component analysis on 13 categories of capital flows restrictions for year 1996. The results of this computation can be seen in *Table 1* and 2.

Variables used in the principal component analysis

CMS	Capital Market securities
MMI	Money Market Instrument
CIS	Collective Investment Securities
DOI	Derivative and Other Instruments
CC	Commercial Credits
FC	Financial Credits
GSFBF	Guarantee Sureties and Financial Backup facilities
DI	Direct Investment
LDI	Liquidation of Direct Investment
RET	Real Estate Transaction
PCM	Personal Capital Movements
PCBOCI	Provisions specific to Commercial Banks and Other Credit Institutions
PII	Provisions specific to Institutional Investors

Table 1

Principal Component / Covariance

Number of obs= 47
Number of comp=13
Trace=2.814061
Rho=1.0000

Rotation: (unrotated=principal)

Component	Eigenvalue	Difference	Proportion	Cumulative
Comp1	1.39812	1.12934	0.4968	0.4968
Comp2	.268788	.0239263	0.0955	0.5924
Comp3	.244862	.0307212	0.0870	0.6794
Comp4	.214141	.0298991	0.0761	0.7555
Comp5	.184242	.0714762	0.0655	0.8209
Comp6	.112766	.0132236	0.0401	0.8610
Comp7	.0995422	.0214447	0.0354	0.8964
Comp8	.0780975	.0139948	0.0278	0.9241
Comp9	.0641027	.009497	0.0228	0.9469
Comp10	.0546057	.0119058	0.0194	0.9663
Comp11	.0426998	.00889596	0.0152	0.9815
Comp12	.0338039	.0155179	0.0120	0.9935
Comp13	.018286		0.0065	1.0000

We can see that the first component accounts for approximately for half of the variance, and that additional components do not bring much more explanatory power to

the analysis. The proportion of each variable retained by the PCA can be observed in *Table 2.*

Table 2

Principal Components (eigenvectors)	
Variable	First Component details
CMS	0.2401
MMI	0.3096
CIS	0.3406
DOI	0.3444
CC	0.3478
FC	0.3785
GSFBF	0.3199
DI	0.1702
LDI	0.0320
RET	0.2071
PCM	0.3184
PCBOCI	0.1582
PII	0.2146

In a second step we use the first component and predict its score. We call this new variable X. Using this new variable X as an explanatory variable we input it into probit and logit models on a dependent variable called Y, and which corresponds to the dummy variable of “restriction exists on payments in respect to capital account” in year 1995. The results of this regression can be seen in *Table 3*.

The results are very significant, which allows us to use this function to predict directly the probability for year 1996. From 1997 to 2005 we repeat the principal component analysis on the 13 categories of capital restrictions for each year, and calculate the score that the first components give. We then replace those yearly new variables -the ones obtained by the first component scoring- into our probit and logit functions shown in *Table 3*. This allows us to predict the probability for each year.

Table 3

Y *dummy variable "restriction exists on payments in respect to capital accounts" in year 1995 (old classification)*

X *Score of the first components from the principal factor analysis of 13 categories of capital restrictions (new classification)*

Independent variable Y	Probit Regression	Logit Regression
X	0.934*** (0.210)	1.614*** (0.408)
Cons	-1.850*** (0.442)	-3.211*** (0.861)

As a result we have 2 databases, the old classification with dummy values 1-0 from 1970 to 1995, and the new classification from 1996 to 2005 with the probabilities. We leave the probability score as it is, assuming this probability measurement as simply being more precise than what we could get prior to 1996, and merge the two databases in one chart. Once we have this complete database we calculate the mean per decades (1970s, 1980s, 1990s, and 2000s) and normalize the values to the mean of the panel.

Unless specified differently, we use the index calculated from the probit function in the econometric analysis of the trilemma.

APPENDIX 3: Details of variables other than ER, MP and CF used in the article

Explanatory variables	Database	Name of the line used in the database	Formula used to transform the data
ln_Inf_rate	WDI 2006	"Inflation, GDP deflator (annual %)"	Transformation applied to inflation rate $\ln INF_{rate} = \ln\left(1 + \frac{INF_{\%}}{100}\right)$
CA_%_GDP	WDI 2006	"Current account balance (% of GDP)" (minus values possible)	Average per period (1970s, 1980s, 1990s, 2000s) of the panel
Openness	WDI 2006	IM= "Imports of goods and services" X= "Exports of goods and services" GDP= "GDP (constant 2000 US $)"	$Openness = \frac{\overline{IM_t} + \overline{X_t}}{\overline{GDP_t}}$ $\overline{IM_t}$ = average value of imports in period t $\overline{X_t}$ = average value of exports in period t $\overline{GDP_t}$ = average value of GDP in period t period t= 1970s, 1980s, 1990s, 2000s
GDP_per_Capita	WDI 2006	"GDP per Capita (constant 2000 US $)"	Average per period (1970s, 1980s, 1990s, 2000s) of the panel
GDP	WDI 2006	"GDP (constant 2000 US $)"	Average per period (1970s, 1980s, 1990s, 2000s) of the panel
Deficit_%_GDP	IFS 2006	For the deficit: Line "…80ZF Deficit (-) or surplus" Line "…80ZW Deficit (-) or surplus" for Euro Area from year 2000. For the GDP: Line "…99B Gross Domestic Product"	Average per period (1970s, 1980s, 1990s, 2000s) of the deficit in terms of percentage of GDP (minus or plus)

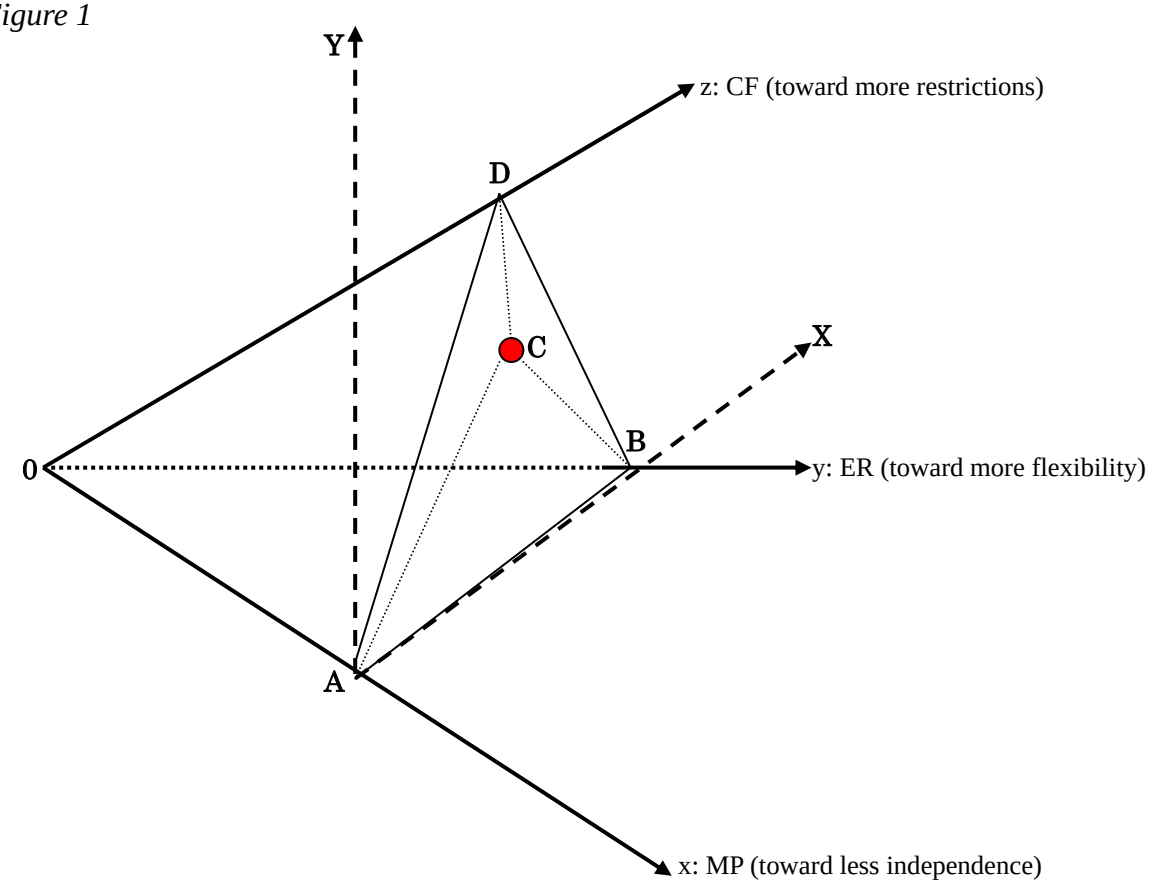
APPENDIX 4: Trilemma performance values per decade for each country

1970s		1980s		1990s		2000s	
	Perf=		Perf=		Perf=		Perf=
Country	INF+CA+FE	Country	INF+CA+FE	Country	INF+CA+FE	Country	INF+CA+FE
Germany	-0.631	Germany	-0.698	Ireland	-0.686	Norway	-0.878
Canada	-0.379	Netherlands	-0.423	Belgium	-0.616	Singapore	-0.688
Belgium	-0.375	Canada	-0.414	Germany	-0.600	Canada	-0.614
Netherlands	-0.360	Belgium	-0.414	Netherlands	-0.478	Panama	-0.572
UK	-0.312	Ireland	-0.367	Norway	-0.478	Sweden	-0.507
France	-0.310	UK	-0.342	Canada	-0.451	Malaysia	-0.504
Ireland	-0.294	Austria	-0.320	Denmark	-0.450	Croatia	-0.504
US	-0.272	Norway	-0.306	Singapore	-0.433	Denmark	-0.490
Austria	-0.262	France	-0.285	France	-0.387	Slovenia	-0.441
Denmark	-0.241	Denmark	-0.247	Slovenia	-0.342	Switzerland	-0.388
Sweden	-0.226	US	-0.210	Finland	-0.317	Morocco	-0.341
Italy	-0.204	Sweden	-0.200	UK	-0.315	UK	-0.309
Australia	-0.147	Italy	-0.168	Austria	-0.309	Peru	-0.308
Finland	-0.143	Finland	-0.163	Italy	-0.287	Saudi Arabia	-0.286
Kuwait	-0.121	Spain	-0.109	Sweden	-0.287	Hong Kong	-0.285
Malaysia	-0.115	Australia	-0.052	US	-0.236	Israel	-0.206
Spain	-0.052	Malaysia	-0.005	Hungary	-0.235	Chile	-0.179
Japan	0.122	Morocco	0.031	Morocco	-0.167	Hungary	-0.177
Brazil	0.126	Japan	0.034	Switzerland	-0.153	Slovak Republic	-0.120
Philippines	0.312	Turkey	0.233	Greece	-0.147	Brazil	-0.118
India	0.363	Singapore	0.248	Czech Republic	-0.144	Czech Republic	-0.113
Thailand	0.509	Philippines	0.275	Spain	-0.109	US	-0.112
Korea	0.511	New Zealand	0.321	Australia	-0.099	Philippines	-0.091
Singapore	0.627	Korea	0.345	Hong Kong	-0.067	Australia	-0.077
South Africa	0.899	Kuwait	0.351	Croatia	-0.065	Poland	-0.060
Argentina	1.300	Mexico	0.361	Malaysia	-0.047	Japan	-0.025
		Thailand	0.455	Israel	-0.039	China	0.025
		India	0.464	Japan	0.010	Thailand	0.044
		Peru	0.519	Poland	0.035	Mexico	0.113
		Portugal	0.553	China	0.083	New Zealand	0.155
		Brazil	0.668	New Zealand	0.146	Colombia	0.175
		South Africa	0.801	Philippines	0.187	Turkey	0.196
		Ecuador	0.812	Mexico	0.250	Korea	0.210
		Indonesia	1.241	Turkey	0.300	Bulgaria	0.344
		Argentina	1.985	Colombia	0.303	Venezuela	0.531
				Korea	0.309	Egypt	0.545
				Peru	0.349	Kuwait	0.614
				Thailand	0.404	Ecuador	0.691
				Saudi Arabia	0.412	South Africa	0.810
				Portugal	0.446	Argentina	0.823
				India	0.453	Nigeria	0.948
				Romania	0.553	Indonesia	0.967
				Egypt	0.558	Russia	1.045
				Bulgaria	0.584		
				Ecuador	0.748		
				South Africa	0.799		
				Brazil	0.827		
				Venezuela	0.849		
				Indonesia	1.181		
				Argentina	1.243		
				Nigeria	1.444		
				Russia	1.908		
				Kuwait	2.074		

APPENDIX 5 : Derivation of the triangle graph

The aim of the triangle graph is to be able to see the policy-mix adopted by each country for the trilemma. In order to achieve this, we express all the points of the 3 dimensional graph into a 2 dimensional graph in which an equilateral triangle of side 1 is drawn. One important assumption we make for building this graphic analysis is that all countries face the same slope for their constraint. Only the distance from the origin can vary from one country to another.

Figure 1



Legend of the figure 1

C: Country in the 3D graph. The point's coordinates are calculated in the triangle that represents the trilemma in the graph (X ,Y).

0 represents the origin of 3D graph and is the ideal state that cannot be reached because of the trilemma rule (since in 0, monetary policy is perfectly independent, the exchange rate perfectly fixed and capital flows completely free).

Variables: MP= monetary policy, ER= exchange rate and CF= capital flows.

The triangle ABD, which is a piece of plane, is represented by the cartesian equation: $x_{MPi}+y_{ERi}+z_{CFi} = a$ where A,B and D have the coordinates *A(a,0,0)* *B(0,a,0)* and *D(0,0,a)*. One can easily verify that these coordinates satisfy the equation: $x_{MPi}+y_{ERi}+z_{CFi} = a$.

Figure 2

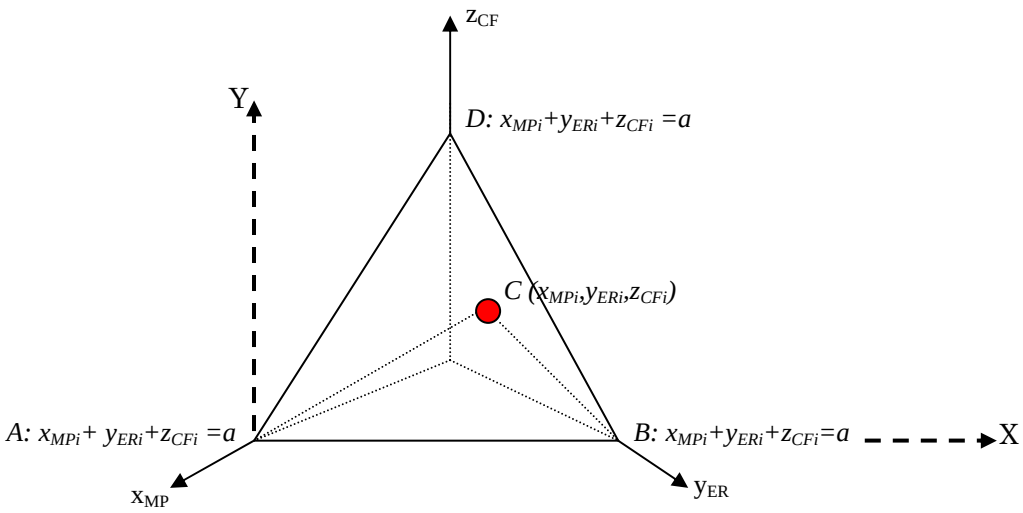
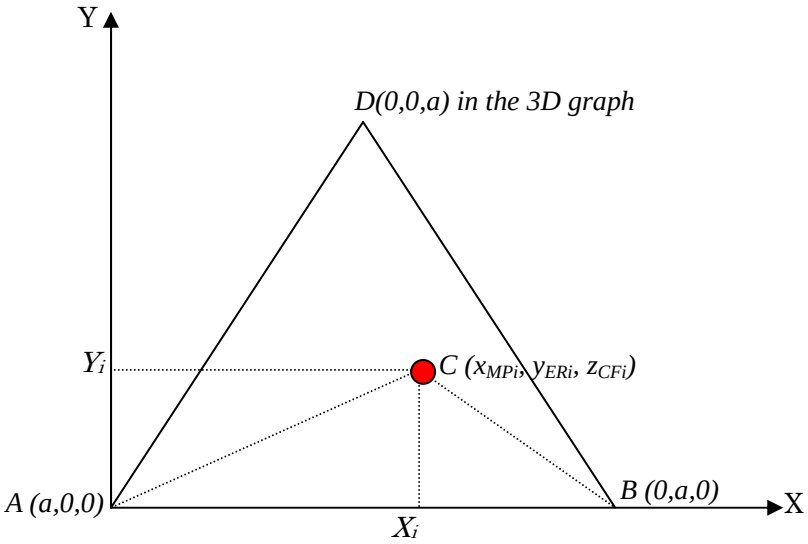


Figure 3



For each country we define the triangle we just explained, express its new coordinates in the two dimensions graph (X, Y), and normalize this triangle to 1 so that we can see each point in this triangle.

The distance $AB = a\sqrt{2}$ (diagonal of a square) since we took the triangle with *A (a,0,0) , B (0,a,0) , D (0,0,a)* coordinates as reference. Given the three measurements that we have for the three variables $x_{MPi}, y_{ERi}, z_{CFi}$ for each country *i* we can calculate:

- <u>from the 3D graph:</u>

$AC^2 = (x_{MPi} - a)^2 + y_{ERi}^2 + z_{CFi}^2$ with the definition of distance AC (1)

$BC^2 = x_{MPi}^2 + (y_{ERi} - a)^2 + z_{CFi}^2$ with the definition of the distance BC (2)

- <u>in the 2D graph we have:</u>

$AC^2 = Y^2 + X^2$ (3)

$BC^2 = Y^2 + \left(a\sqrt{2} - X\right)^2$ (4)

(12)-(13) gives us:

$AC^2 - BC^2 - X^2 + (a\sqrt{2} - X)^2 = 0$ (5)

$AC^2 - BC^2 + 2a^2 - 2a\sqrt{2}X = 0$ (6)

$$X = \frac{AC^2 - BC^2 + 2a^2}{2a\sqrt{2}}$$ (7)

and for Y directly from (12):

$Y = \sqrt{AC^2 - X^2}$ (8)

Having the formulas of AC^2 and BC^2 being expressed in (1) and (2) we can easily calculate the value of X and Y in terms of the value *a* and the 3 coordinates, i.e. the values of the indices.

- <u>then in a last step a we normalize X and Y to 1 by dividing by</u> $AB = a\sqrt{2}$.

$$X_{norm} = \frac{1}{a\sqrt{2}} X \quad (9)$$

$$Y_{norm} = \frac{1}{a\sqrt{2}} Y \quad (10)$$

By normalizing to 1, we changed the coordinates so that the point in the triangle is represented in the equilateral triangle of measure 1 for each side. It can allow us therefore to see countries' policy-mix. Since we express the coordinates into a 2 dimensions graph the information concerning point D is redundant and we do not need to use it.

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